Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

FEBRUARY 1959

VOLUME 42 • NUMBER 2

STOP PROFIT ROBBING PLUG DAMAGE

INSTALL
EMERSON STAINLESS STEEL JACKETS
the Papermaker's Profit Protector

The Papermaker has discovered it costs no more to have an old plug jacketed with Emerson special formula stainless steel than to buy a new one of cast iron or steel. Regardless of a plug's condition, make, size or style, an Emerson stainless steel jacket can be installed *to add years of life* to any Jordan plug.

Mills coast to coast stop structural damage and corrosion in Jordan plugs by having them completely encased in stainless steel. This exclusive Emerson jacketing process, as a maintenance investment, features new bandless, continuous slotted construction. Any size cutting edge may be used interchangeably in the same plug.

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Is Jordan plug damage cutting into your profits? Write today. *The Emerson Manufacturing Co., Division, John W. Bolton & Sons, Inc., Lawrence, Massachusetts.*

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- ★ Container Corporation of America
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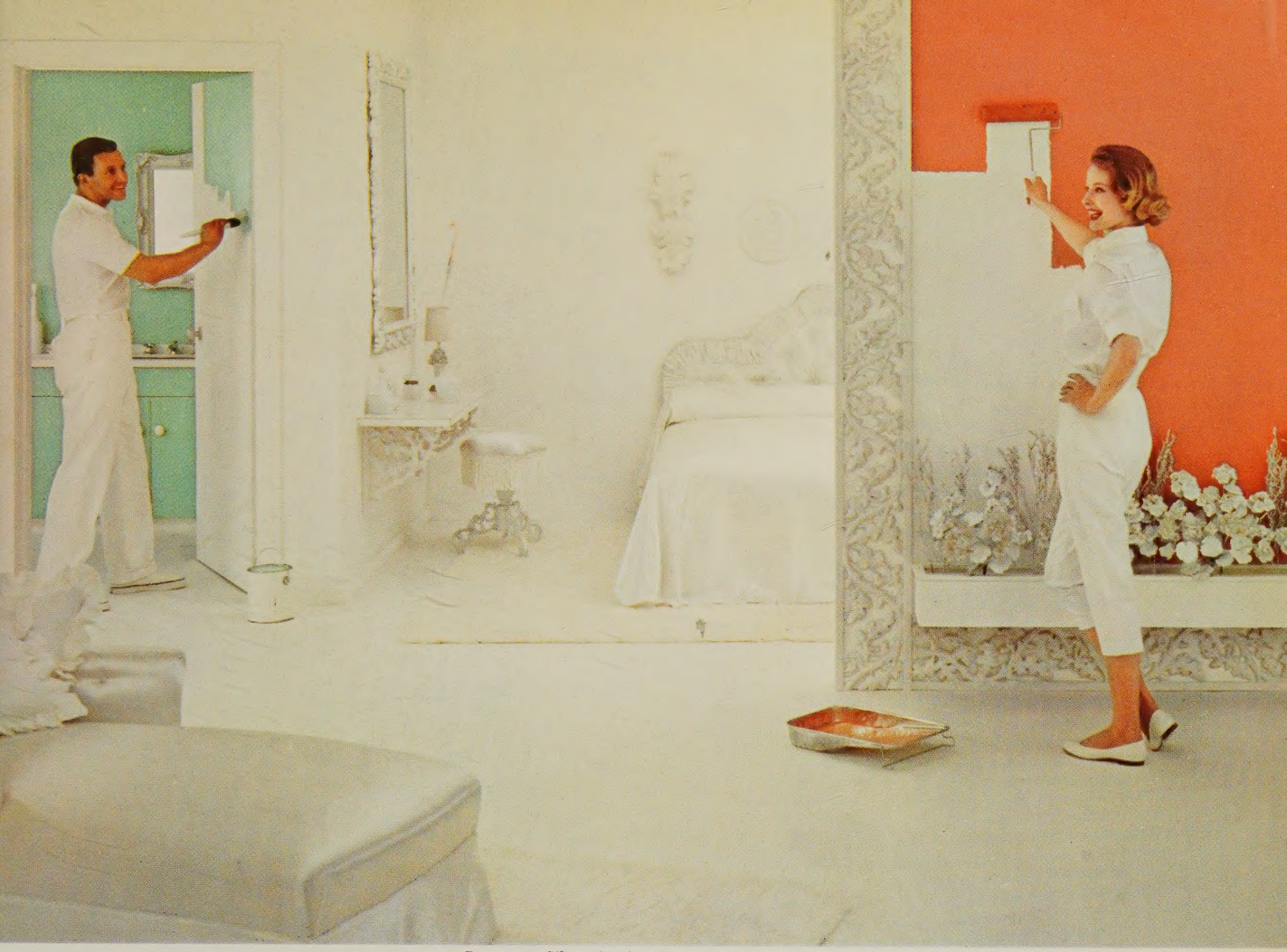

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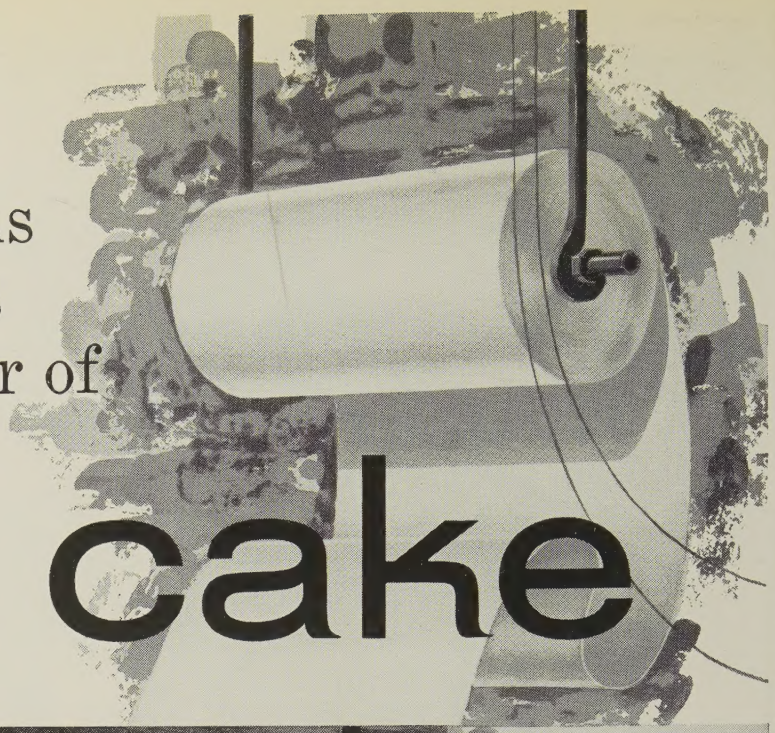

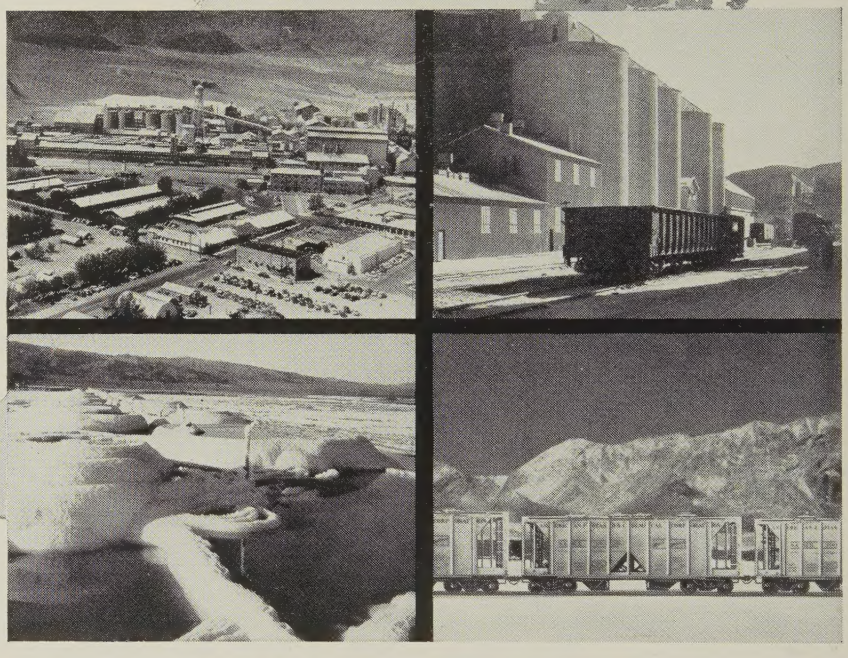

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Look for an early announcement of the start-up of American Potash & Chemical Corporation's new sodium chlorate plant at Aberdeen, Mississippi, constructed to supply the rapidly growing southern pulp and paper industry.

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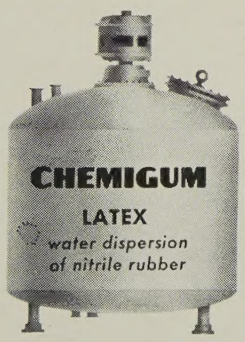
Today, the latest is spelled: L-a-t-e-x

It's true! Many of the latest developments in paper are being accomplished through the use of synthetic latex in the form of impregnants, saturants, coatings and adhesives.

Take the kraft paper shown above. It's being saturated with a combination of CHEMIGUM LATEX and PLIOLITE LATEX for ultimate service as top-quality paper tape. The CHEMIGUM LATEX is used to impart toughness, tear resistance, flexibility and good internal bonding. The PLIOLITE LATEX is used as a reinforcing agent to increase tensile, while decreasing elongation and tack. And both exhibit excellent stability and full compatibility with other materials for ease of processing.

In addition to tapes, rubberized or latex-saturated paper finds many other uses—extra-durable book paper, gasketing, industrial wrapping, artificial flowers, simulated leather. Whatever your product, it will pay you to know more about CHEMIGUM LATEX and the other latices in one of the most complete lines currently offered. For full details, including the latest *Tech Book Bulletins*, write to Goodyear, Chemical Division, Dept. B-9432, Akron 16, Ohio.



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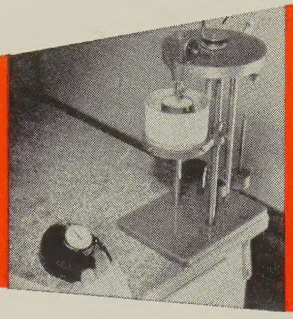
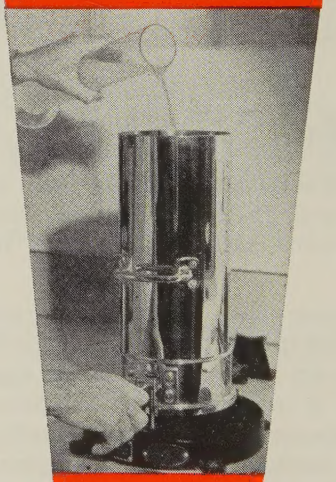


HUBER EXPANDS GEORGIA PAPER LABORATORIES

As it has from its inception, the Huber, Ga., laboratory maintains a close relationship with customers through our Technical Service department. As our Georgia operations—and service to our customers—have grown, our laboratory has been enlarged to provide ever better service.

The largest of the Huber Paper Laboratory expansions was recently completed. The laboratory is equipped and manned to conduct the same kind of work that our customers perform in their own laboratories. We duplicate all of the essential stages of paper making from sheet to finished filled or coated paper.

If you would like to learn how the Huber Paper Laboratories can improve *your* product, we will be glad to sit down and discuss it with you.



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FEBRUARY 1959

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The Technical Articles are in accord with the recommendations of the Division of Pulp, Paper, and Board of the International Union of Pure and Applied Chemistry.

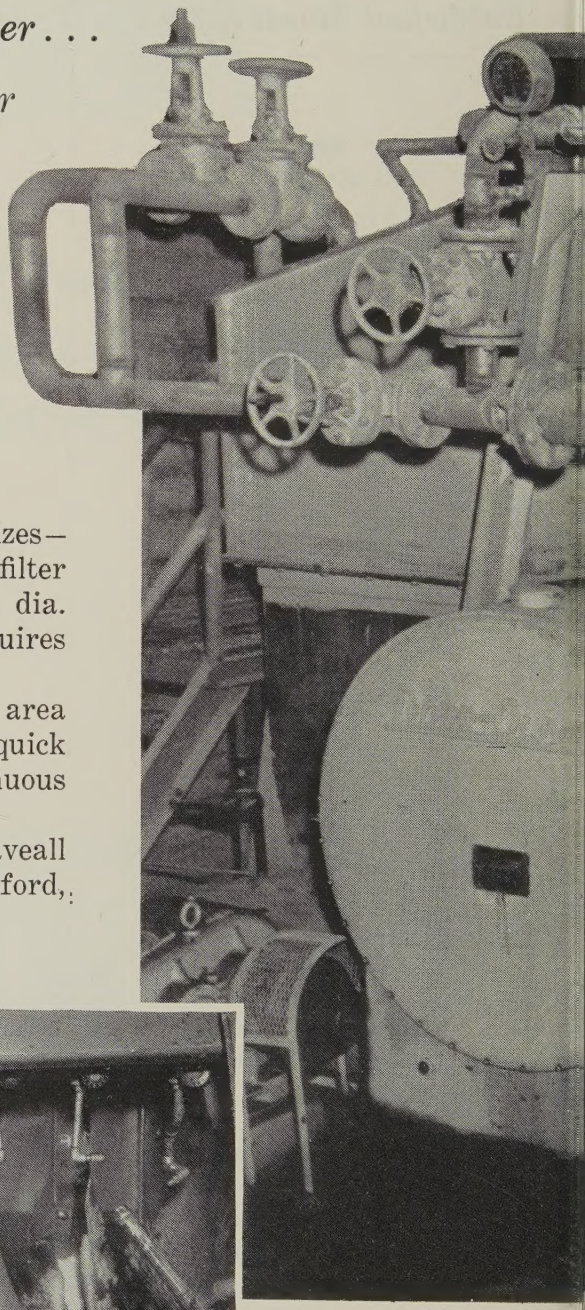
AMERICAN (DISC-TYPE) SAVEALLS

at Scott Paper Co., Everett, Washington,

handle 8,000 gpm of white water . . .

show excellent recovery . . . only 0.5 lbs. fiber

1,000 gpm remains in effluent

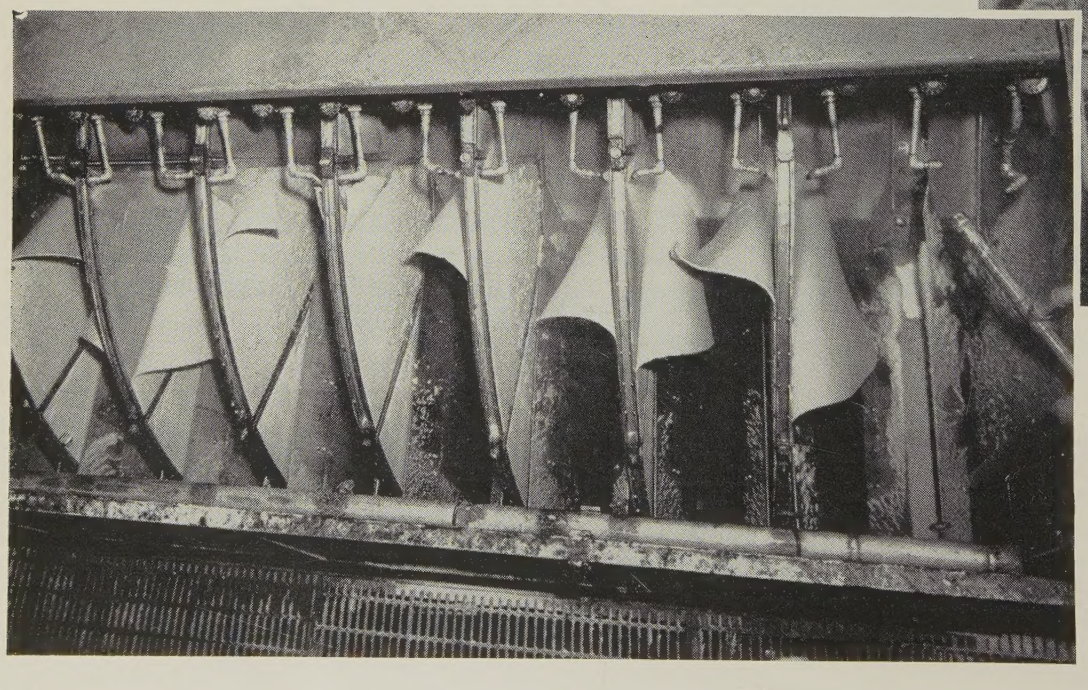


Four American Savealls, each 9 ft. diameter with 10 discs, are installed in the Scott Paper Company mill at Everett, Washington. With only 8 of the 10 discs in operation in each machine, a total of 8,000 gpm is handled. The experience of Scott Paper Co. shows excellent recovery . . . only 0.5 lbs. fibre per 1000 gallons of clarified water.

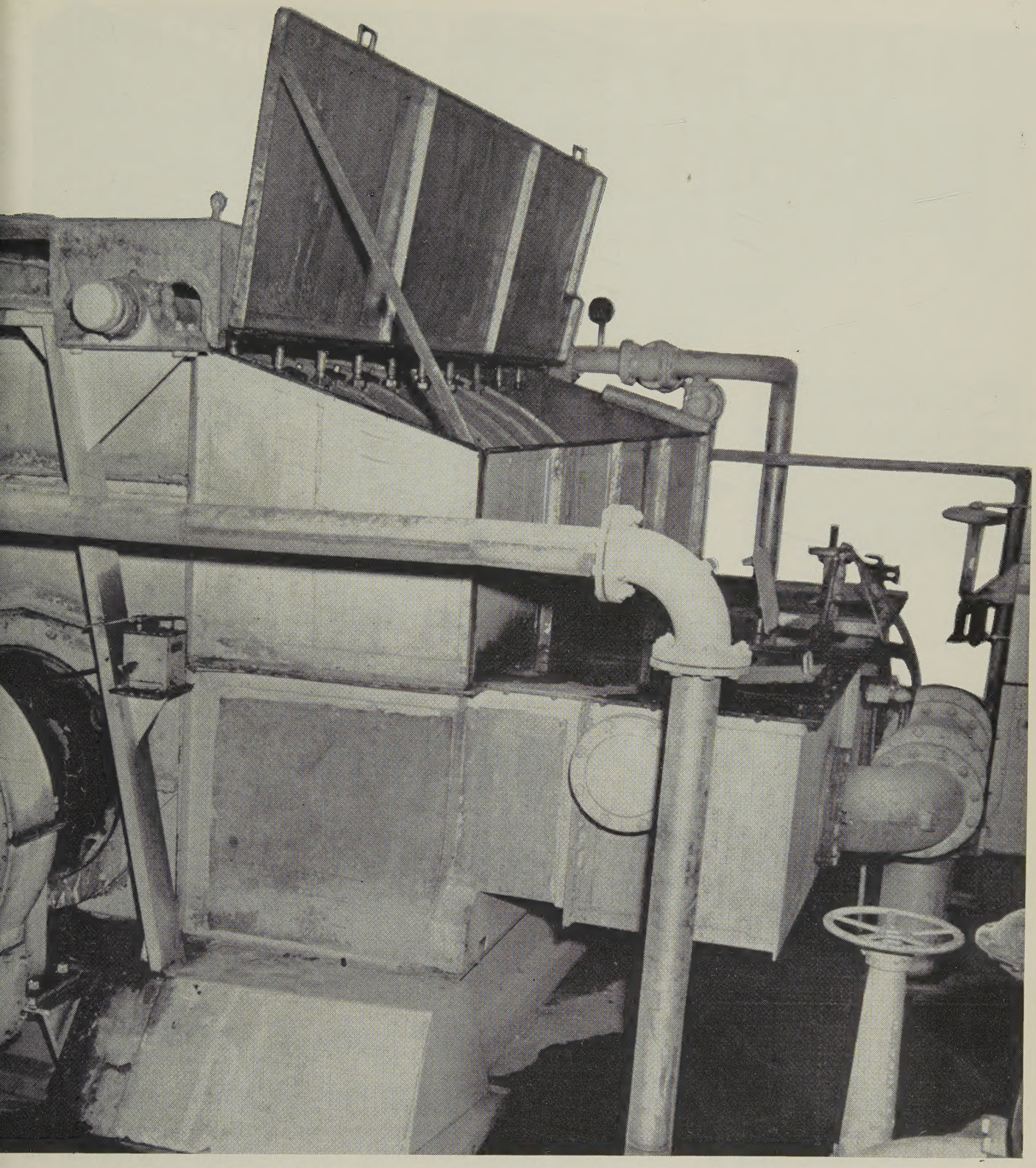
The American Disc-Type Saveall is available in two sizes—9 ft. dia. with a maximum of 12 discs having 1320 sq. ft. filter area requires only 23 ft. x 12 ft. floor space, and 7 ft. dia. with a maximum of 8 discs and 560 sq. ft. filter area requires 8½ ft. x 15½ ft.

Outstanding operating advantages include–large filter area and high capacity with minimum floor space, easy and quick replacement of disc sectors, and fully automatic and continuous operation.

For more information on the American Disc-Type Saveall write for Bulletin 701-R. Dorr-Oliver Incorporated, Stamford, Connecticut, U. S. A.



Close-up shows how the sluicing jets cut under the sheets and peel or slice them off. The fine fibers and costly fillers are then returned to the stock chest with the sheet.



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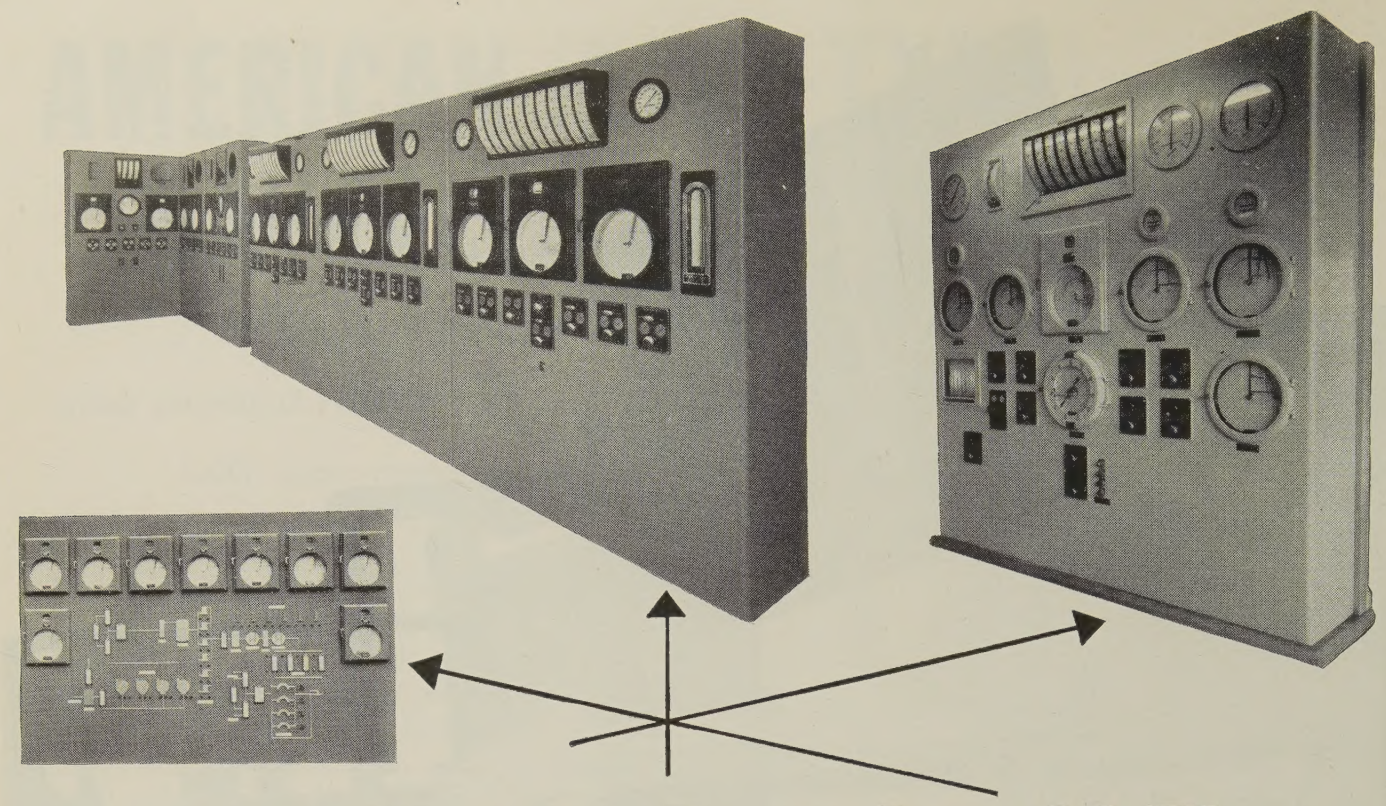

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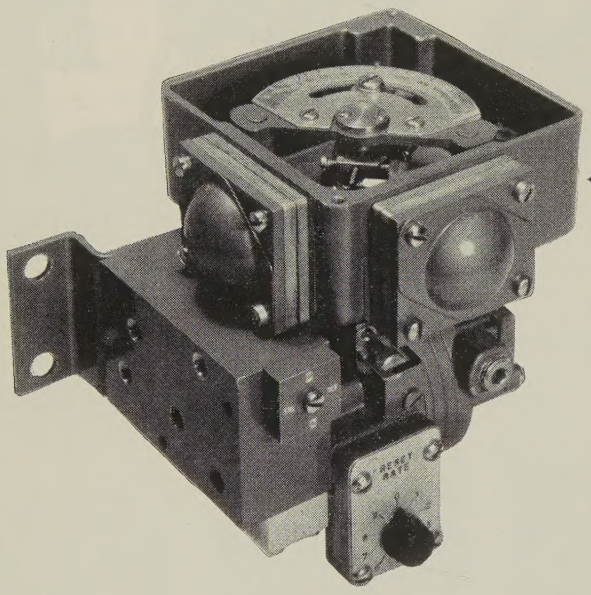

ON THIS

For accurate, efficient, dependable control systems— REPUBLIC'S NEW TYPE "VC" PNEUMATIC CONTROLLER

Here is an all purpose null-balance-vector controller for use with any pneumatic transmitter. Its proportional band ranges from 2% to 500% *without changing parts*, for quick adaptation to changes in process requirements. Especially important in high-precision control, Republic's Type VC has exceptional sensitivity and a narrow dead band (less than 0.05%). Its high capacity non-bleed pneumatic amplifier consumes little air, keeps output ample. A selector block permits reverse or direct action; local or remote pneumatic set point optional.

Companion instruments—using an identical null-balance-vector "heart"—include differential pressure, temperature and pressure transmitters . . . ratio, totalizing, multiplying, squaring and square - root - extracting relays. Many parts are interchangeable among the instruments in this "family". Besides reducing spare parts inventory, the similarity of components simplifies the task of training personnel.

Let a Republic engineer show you how these instruments can help to achieve accurate, efficient, dependable control systems. Republic Sales Offices are located in principal cities throughout the U.S.A. and Canada.

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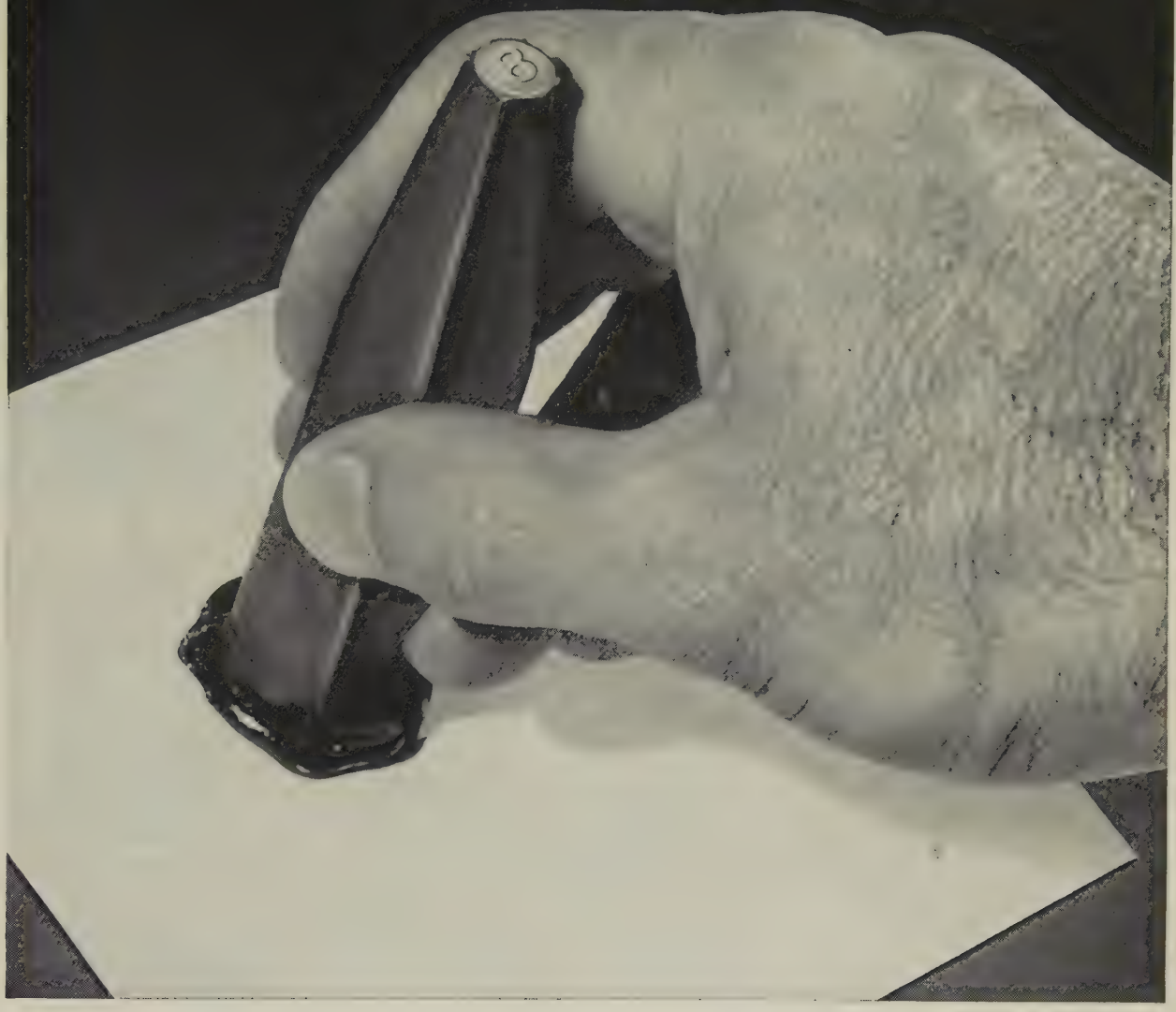

WAX-PICK TESTS PROVE...

Staley's new Stadex® Dextrin 140 gives greater binding strength in higher-solids coating colors

Higher adhesive quality! Now you can use high-solids coatings of low viscosity *without sacrificing surface strength.*

Staley's new improved Stadex Dextrin 140 solves the problem of poor binding strength in high-solids coatings once and for all. Stadex Dextrin 140 is a high-solids clay coating adhesive with excellent stability, viscosity and binding strength characteristics. Used in combination with Stayco® (oxidized) starches, Stadex Dextrin 140 produces a coating of high adhesive quality.

Long a standard in the paper industry, Stadex 140, like all Staley dextrins, is now made by a brand new dextrinization technique that guarantees you even better adhesives of top quality, minimum color and unparalleled uniformity.

Why not get the full story on Stadex 140 for yourself now?

See your Staley representative or write us for details today.

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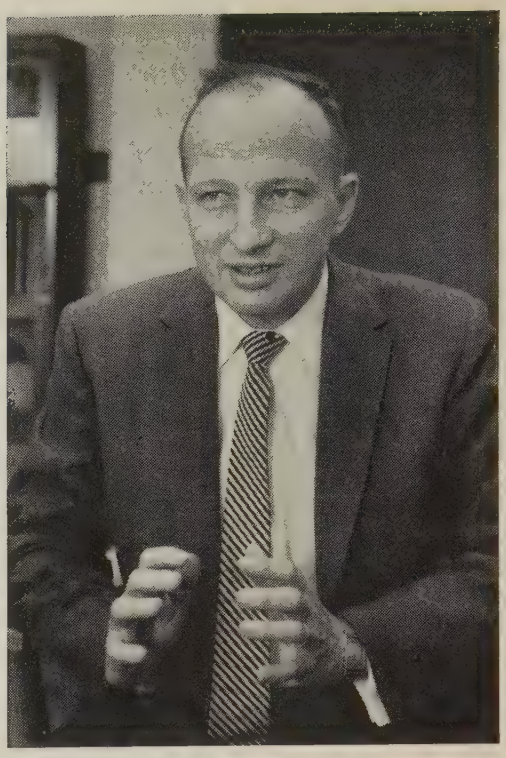
One in a series of interviews with the men who are "Virginia"

"Bleaching groundwood pulp with hydrosulfites can be done easily—with minimum capital investment—for less than $6 per pulp ton, including chemicals and steam for heating"



Robert Barton, a "Virginia" technical representative

Simplicity of operation, low cost, high pulp brightness—these factors have attracted many groundwood pulp processors to the use of either sodium or zinc hydrosulfite as their principal bleach agent.

The advantages of hydrosulfite bleaching are discussed by Robert Barton, a technical representative of Virginia Smelting Company.

Q How does the cost of bleaching with hydrosulfite compare with the cost of oxidizing bleaches?

A Extremely well. The cost of using zinc or sodium hydro usually runs less than one-half that of the oxidizing bleaches, and with equally good results.

Q Just what is the brightness gain using hydro?

A That question has to be qualified somewhat, I think. You see there are factors that have to be considered in bleaching groundwood pulp with hydro —the *p*H of the stock, temperature, reaction time, iron content of the pulp and of the process water. But with reasonably good conditions, single-stage bleaching with hydro will result in about 10 or 12 brightness points gained.

Q Does installation of equipment present any problem?

A Not at all. Most manufacturers who have gone to the hydro bleaching process are well pleased with the simplicity of the installation. And at the low cost, I might add. Generally they can use existing chests and pumps in their plants —adding necessary piping. Not much more is needed.

Q Do the hydrosulfites offer any advantages to a manufacturer now using peroxide for his bleach?

A Very definitely. In our laboratories at "Virginia" we have helped develop the 2-stage bleach for groundwood pulp that gives an absolute maximum brightness—at a cost that cannot be touched by any other method.

Q How does this 2-stage bleaching work?

A Well, for brightness gains up to 12 points, of course, the single-stage hydrosulfite bleach is the most economical. But for gains from 12 to 20 points, we recommend a 2-stage bleach. The first stage is a peroxide bleach. We follow that with a sulfur dioxide treatment to remove any residual peroxide in the slurry. This is followed by a hydro bleach. We will be happy to furnish all the data to anyone interested in this process.

Q Does "Virginia" offer technical assistance to any manufacturer interested in either the single-stage or 2-stage bleach process?

A A great deal. Our experience in this field is long and extensive, and available to anyone interested. For preliminary bleaching studies, we maintain a complete pulp laboratory at our plant. To solve certain types of problems, we obtain pulp samples, make laboratory bleaches, study the brightness gains along with any contributory factors, and make a complete report to the manufacturer. Along with the report go our recommendations—and of course our laboratory men are quite impartial in their findings. If the manufacturer has a process involving problems that make hydro impractical for any reason, we will tell him so quite frankly. But this occurs very infrequently. We welcome inquiries from any manufacturer interested in exploring the possibilities of hydrosulfites in pulp bleaching.

• • •

FOR MORE DATA ON HYDROSULFITES

write to us on your company letterhead describing your present bleaching process, giving full details wherever necessary. We will send you pertinent technical bulletins from the extensive "Virginia" library of literature on pulp bleaching. If you prefer, we will have a "Virginia" man call on you.

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Super GM-1000-M LAMINATOR

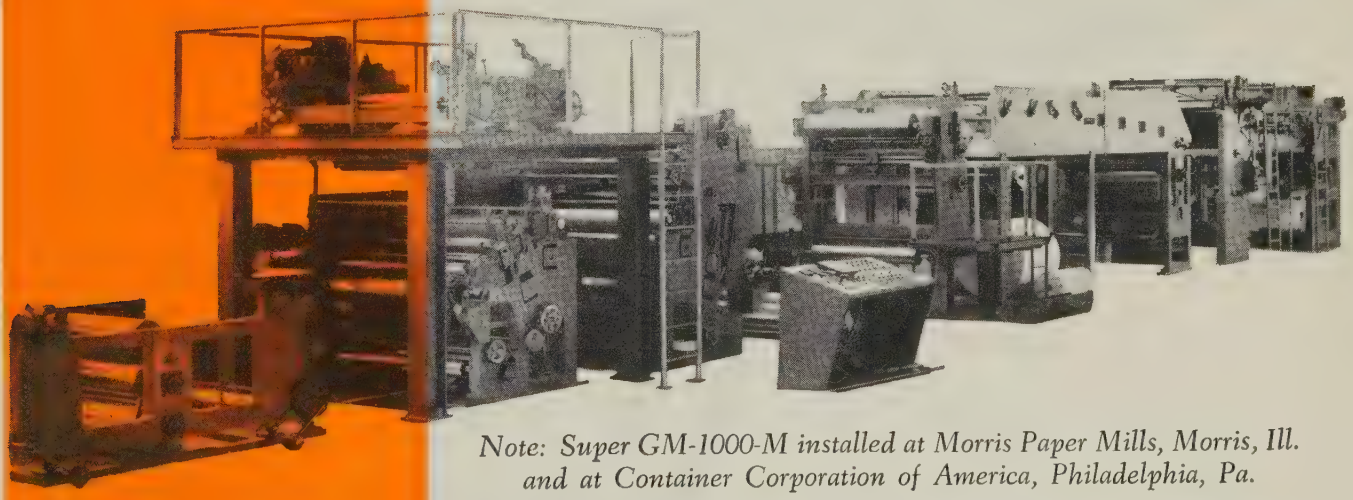
for Laminating
Paperboard
Paper
Film
Foil

The New Super GM-1000-M is designed to laminate foil or paper to one or both sides of paperboard, coat, color or treat one side by Flexographic process as well as either side by Rotogravure process with provision for cutting into sheets or rewinding into rolls.

The New Super GM-1000-M includes double unwinds for 30″ O.D. rolls of paper, single unwinds for 18″ O.D. rolls of foil, double unwind for 60″ O.D. rolls of paperboard, two glue mounting units, one Flexographic and one Rotogravure printing station with drying tunnel, sheeter and layboy for 51″ x 70″ maximum size sheets as well as rewind for 63″ O.D. finished rolls.

The New Super GM-1000-M is equipped with constant tension controls, side guide controls, hydraulically operated impression units, electric eye on sheeter and layboy and is driven through synchronized electric motor drive with all controls and indicators mounted on a master console control cabinet.

The New Super GM-1000-M is available in different widths and is designed for speeds up to 400/500 feet per minute. Additional details are available upon request. Write today.



Note: Super GM-1000-M installed at Morris Paper Mills, Morris, Ill. and at Container Corporation of America, Philadelphia, Pa.

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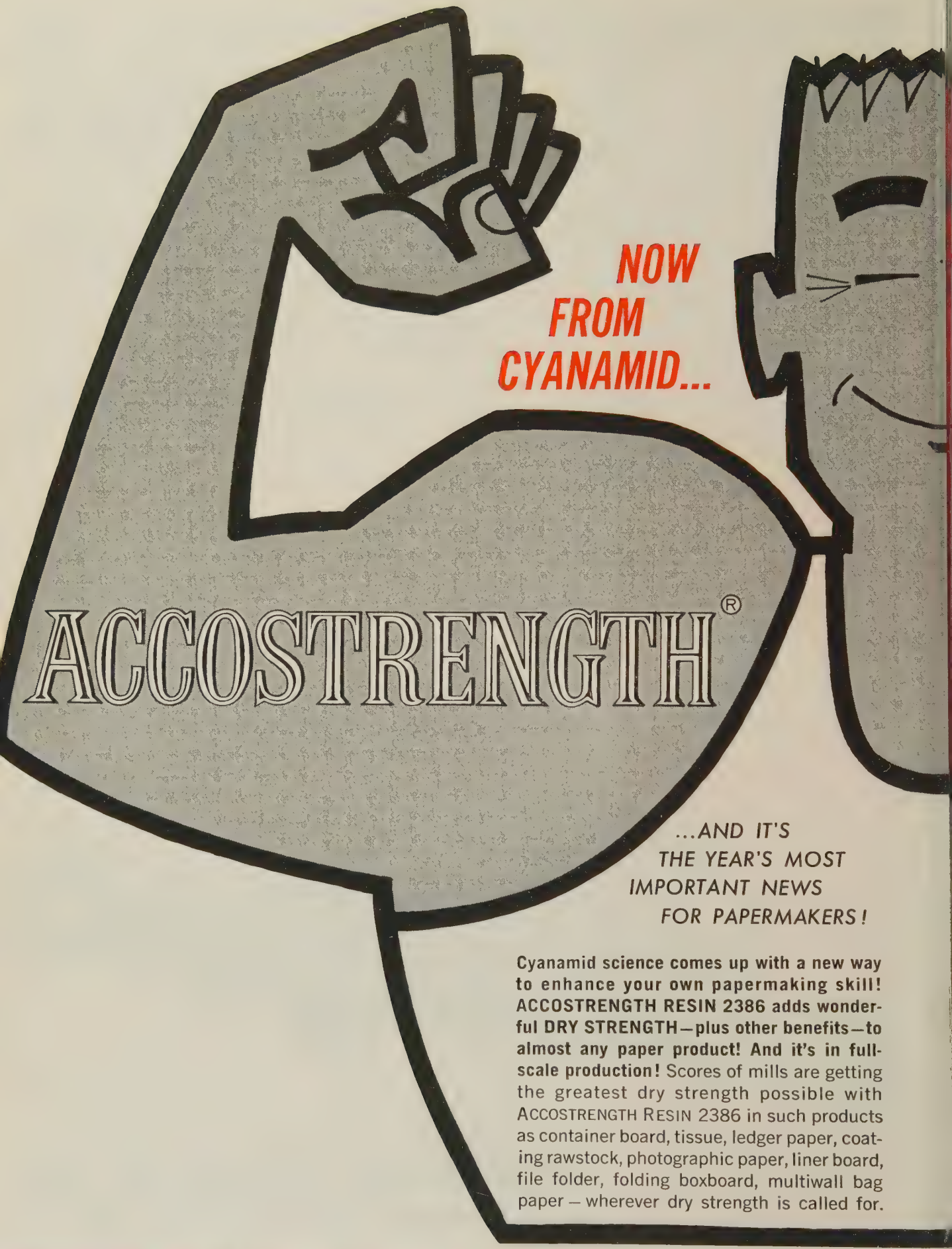
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Cyanamid science comes up with a new way to enhance your own papermaking skill! ACCOSTRENGTH RESIN 2386 adds wonderful DRY STRENGTH—plus other benefits—to almost any paper product! And it's in full-scale production! Scores of mills are getting the greatest dry strength possible with ACCOSTRENGTH RESIN 2386 in such products as container board, tissue, ledger paper, coating rawstock, photographic paper, liner board, file folder, folding boxboard, multiwall bag paper – wherever dry strength is called for.
AMERICAN CYANAMID COMPANY, PAPER CHEMICALS DEPARTMENT, 30

ACCOSTRENGTH RESIN 2386 is easy to use, too. Doesn't create foam... helps carry more water (better sheet formation)... improves drying... permits substitution of hardwood for pine... raises tensile and bursting strength, with better folding endurance. Dimensional stability goes up, too!

Full-scale production brings ACCOSTRENGTH RESIN 2386 down to new, economic price levels. It's easier than ever to offer improved quality that draws people to your brand—again and again! Call us for the facts!

OCKEFELLER PLAZA, NEW YORK 20, NEW YORK

CYANAMID

The Paper Industry in 1958—and 1959

FREDERIC L. GRAYSON

THE performance of the pulp and paper industry during 1958 conformed rather closely with that of industry as a whole, following the recession down to its low point in April and recovering steadily through the latter months of the year. More particularly, changes in paper industry activity in 1958 were, as usual, closely similar to those in the nondurable goods sector of the manufacturing economy, which felt the recession considerably less than was the case with durable goods. Thus while the drop in over-all industrial production was nearly 14% from its historic peak in February, 1957, to the trough in April, 1958, and the comparable drop for durable goods alone was over 20%, nondurable goods activity was down less than 6%, and paper and allied products less than 7%.

Total production of paper and board in the first six months of 1958 ran $3^1/_2$% behind the 1957 first half; in the second half of 1958, however, production picked up markedly (October production, for instance, was the greatest of any month in the industry's history), and final figures will probably show that 1958 production closely approximated the 30.7 million tons produced in 1957. This is some 2% behind the all-time production record of 31.4 million tons set in 1956, which was a year of inventory build-up during which production outran actual consumption. In 1957 and much of 1958, on the contrary, inventories were being drawn down at the various consuming levels, with the result that consumption ran ahead of demand during this period.

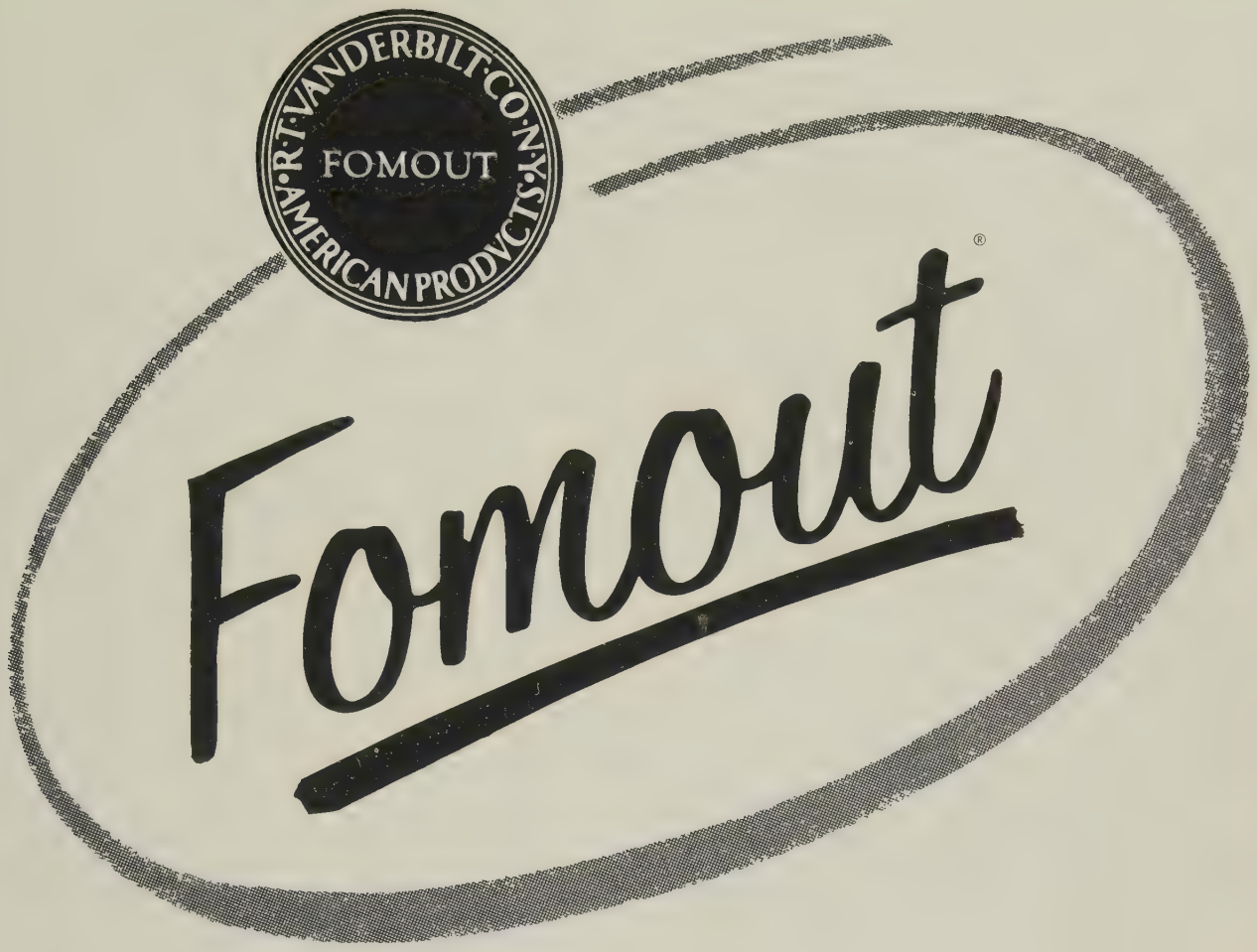
According to our Association's financial survey of 96 companies, accounting for nearly half the total sales of the paper and allied products industry, net sales in the first nine months of 1958 were just 1% behind 1957; and there appears to be a good chance that total 1958 sales may have slightly surpassed 1957 sales. The same is not true of profits; 1958 net profits at the end of nine months were running more than 15% behind comparable 1957 profits, and it is not expected that fourth-quarter earnings will change the picture greatly. Many factors appear to have contributed to this reduction in profits; increased labor costs per ton, higher materials costs, and higher freight costs are some of the factors involved. Also, the ratios of production to capacity for paper and paperboard in 1958 were 87 and 86, respectively, as against 91 and 90 in 1957. As you know, there is a very close relationship in the paper industry between rate of operations or equipment utilization and rate of profitability. This, then, was the picture in 1958: production and sales about equal to the previous year, but profits down, despite generally firm price levels, due to a combination of increased costs and reduced operating rates.

Before attempting to forecast the paper industry's performance in 1959, it might be well to review the outlook for the economy as a whole, since every sector of the economy finds the products of the paper industry essential to its operations. As you know, the general feeling for 1959 is guardedly optimistic. At a recent Conference Board meeting of 15 top-level economists from industry and finance, opinion was general that 1959 would see a continuation of the current rise, though perhaps at a slightly slower rate than in the last few months, and that the second half of 1959 would probably show improvement over the first half of the year. Gross National Product for the fourth quarter of 1958 just past, is estimated at $450 billion (annual rate), which would be an all-time high; and the Gross National Product is projected at about $460 billion for 1959 as a whole, some 5% above 1958, and rising to an annual rate of $470 to $480 billion in the fourth quarter of 1959. Expenditures for new plant and equipment, which were sharply reduced during the recession, are now picking up again, with large sums once more being spent for the replacement of old plant, and on new equipment for new products. Indications are that personal income, disposable income, and personal consumption expenditures will each be up approximately 5% in 1959 over 1958, and that consumer confidence, which was well maintained throughout the recession and cushioned its effects to a considerable degree, will continue into the new year.

As an integral part of the expanding economy, the paper industry will, I believe, make a good showing in 1959. Inventories have been reduced sufficiently to warrant the belief that, for much of the year at least, demand will be based upon actual consumption, and that production will accordingly rise to a new historic high of 32 to 32.5 million tons, about 5% ahead of 1958 production and 2 to 3% above the previous peak of 1956. Dollar sales of paper and allied products should also reach a new high this year, totaling about $11 billion.

The outlook for profits in 1959 is mixed. Increased production and sales, coupled with economy measures pushed during the recent recession, suggest the possibility of modest profit increases in 1959, and the maintenance of strong investor confidence in the industry. On the other hand, the costs of the basic factors of production and distribution will almost certainly continue their upward climb in 1959, and there still remains the problem of excess capacity in some segments of the industry. We are now completing the current edition of our annual capacity survey, which is carried out in cooperation with the National Paperboard Association and the U. S. Department of Commerce, and involves a careful polling of the individual mills as to their expansion plans. While some checking remains to be done, it appears that the over-all production-to-capacity ratio for the industry in 1959 may be about

FREDERIC L. GRAYSON, Associate Economist, American Paper and Pulp Association, New York, N. Y.



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the same as in 1958; that is, 86 or 87%, or a few percentage points below the level which has led to good profits in the past. It is of course entirely possible that as the year progresses, some of the plans for new capacity may be deferred, resulting in somewhat higher operating rates for the year. It is expected, in any case, that increased demand for the industry's products during the years immediately ahead will result in effective utilization of any temporary overcapacity which now exists.

Despite our rising population and expanding economy, the growth of this industry in 1959 and future years cannot be taken for granted. The time-honored cliché in our business—that paper is a substitute for many materials, but that there is no substitute for paper—is no longer true. Many substitutes for paper have been developed, and more are appearing all the time; volume of these materials is going up, and manufacturing costs are coming down. Films, foils, and other plastic materials are competing strongly for markets presently supplied by the paper industry, and since the industries producing these materials are still in the process of reducing costs, the time is approaching, if it is not already here, when the prices of competitive films and foils will limit the price at which papers designed to perform similar functions may be sold. Thus, in some segments of our industry, we are faced with a potential two-way squeeze—demand for some products may grow more slowly than in recent years and, despite rising costs, the prices that can be maintained for these products may be limited by the prices of competing materials. The great positive factor in this picture is that there appear to be wide opportunities, particularly in the dynamic packaging field, for paper and board to be used in combination with these other materials, so that the products of the paper industry and the films and foils may be expected to enhance each other's usefulness and growth.

The answer to competition, and the key to continued growth, lies in research, both market research and product development. Market research has become a more and more valuable tool for decision-making in the industry in recent years, and has played an important part in establishing the trend toward integration, which was continued in 1958, and which has undoubtedly had important stabilizing effects upon the industry. As regards product improvement and new product development, there is evidence that until quite recently the paper industry had been too little concerned with these areas of research. In 1956, the most recent year for which complete data are available, the paper industry spent about $40 million for research and ranked far down the list of industries in this regard. Though $40 million is a lot of money, it was less than half of 1% of the industry's sales dollar in 1956, and compares not at all well with the allocation by several large chemical companies, for example, of 5% or more of their sales dollars to research each year. Happily, it appears that the importance of product improvement and new product development is now fully realized in the industry, and because this is a most interesting and dynamic area, I would like to take a moment to quote the words and doings of a few top executives which have appeared in print during recent days. Perhaps you will recognize them.

The head of a large packaging company says: "In the next ten years, domestic help will be almost nonexistent, and housewives wash an average of 150 dishes a day. Families are getting bigger, and more wives are working. The growth in convenience foods is going to be terrific. We're just at the beginning of the era." He estimates that packaging in the food industry today is a $6 billion market; by 1965 he expects it to be $9.5 billion. Also, this gentleman expects potential profits from new products, such as plastic-coated punch cards that would last longer than present business machine cards, and paperboard containers for oil. In his office are six paperboard containers, shaped like milk cartons, which have held oil for a year. Presumably, they haven't leaked yet.

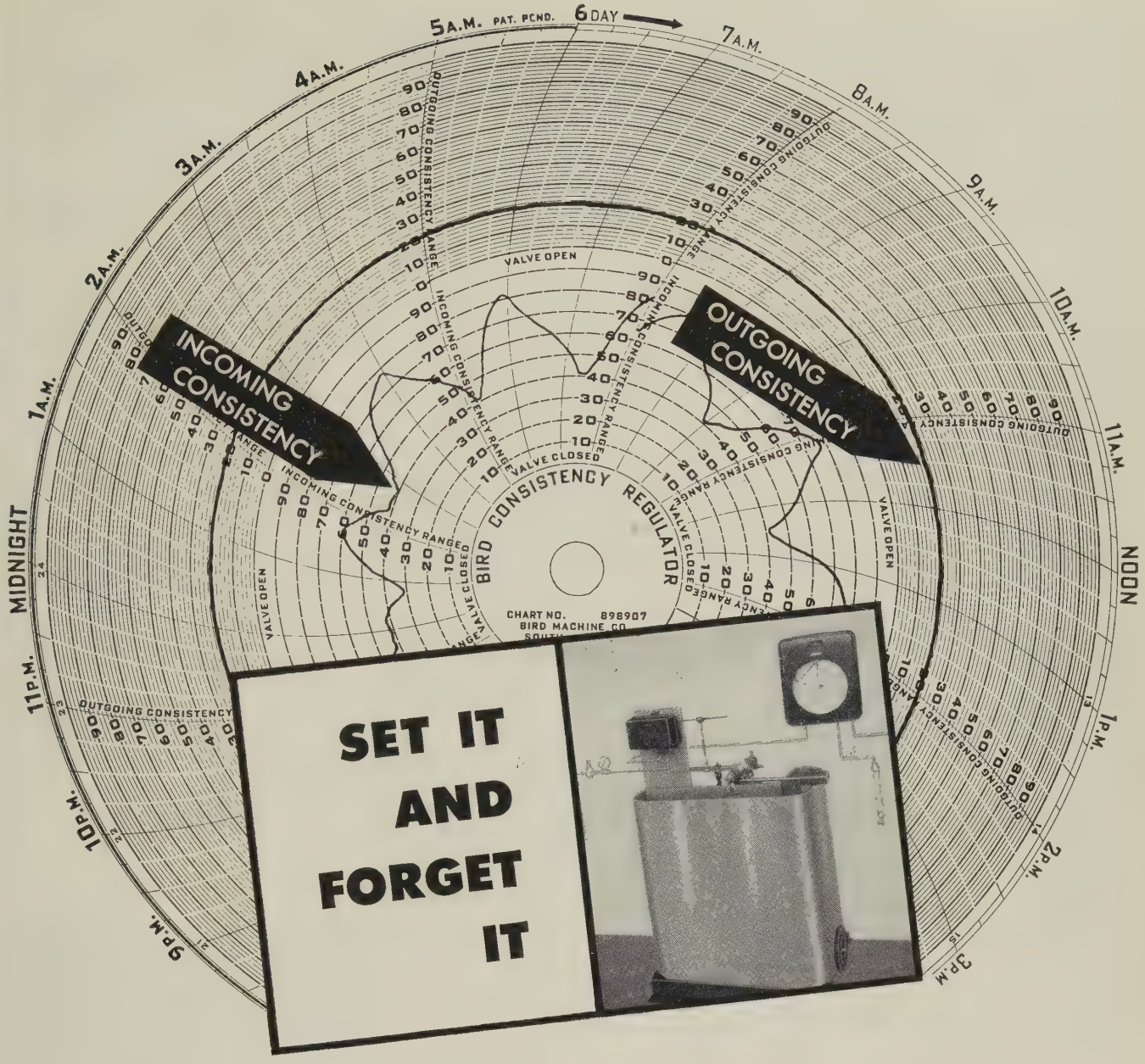
The head of another large packaging concern is quoted as saying that containers made from a combination of paper and plastics hold the potential in the packaging field. He adds that his company has not entered the glass container field because "we believe the future lies in products that compete with glass."

The president of a large paper company states, in his year-end review and forecast: "In addition to the anticipated increase in consumption of present paper products, the future holds great promise in terms of new and improved papers. Research has already made great strides in this direction, even though research is still a comparative infant in the paper industry. If the industry's growing awareness of the need for research is translated into constructive programming—both in the expansion of research facilities and in marketing plans—then no question remains in my mind about the future of the paper industry.

"For a number of years now we have been emphasizing to an extraordinary degree our new products research program, and we have developed several new products from cellulose and other raw materials, which have, we believe, extraordinary consumer appeal. We have also been making intensive market studies into improved methods of introducing and promoting new products. After careful study of the long-range opportunities open to us through research, I think it is safe to say that our budgets for this important activity will probably be increased by as much as 100% over the next 5 years."

These quotes look to the future, but it is also well to remember that the year just past had its share of striking new developments. The growth of interest in stretchable paper, for instance; the introduction of glueable polyethylene coatings for wraps, bags and cartons; the combination of a kraft paper base with thermoplastic adhesives, the combined material capable of stretching as much as 60% in the formation of molded decorative boxes and food containers; a new wax-impregnated corrugated board with remarkable moisture-resistance; and many others which you are no doubt more aware of than I.

The paper industry, as you know, is a big industry which has grown enormously in the postwar years. There are currently about 250 pulp mills and 700 paper mills operating in 40 states of the Union. The total tonnage of paper and board produced in each year is greater than the tonnage of automobiles produced in this country. Since 1947, nearly $6 billion have been



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PLASTIC PIPE AD WITH NO PICTURE?

Why no picture: Because almost all plastic pipe looks the same. You know yourself that looks can be mighty deceiving, and piping that goes wrong can be mighty expensive. A picture means nothing... but...

There are scores of brands of plastic pipe on the market... made of a dozen different kinds of materials. Most of it is labeled "corrosion-resistant" but the results may be good, bad or indifferent depending on your choice. A picture is no help. Here's what to look for instead:

The universal material? No such thing. No one plastic can handle all liquids and gases... no one has *all* the physical properties required of a truly universal pipe. Closest to it are Ace Riviclor (Rigid PVC) and Ace-Ite (rubber-plastic blend). The former is a little better on chemical resistance, the latter is a little better on impact strength and heat resistance. Both same price.

Are plastics strong enough? Thousands of chemical plants say "yes". Pipe is now available in several wall thicknesses... in flexible tube sizes (Ace-Flex clear transparent), up through gas-tubing sizes (Ace-Ite and Ace Riviclor), through flexible Supplex polyethylene pipe, and Schedules 40 and 80 rigid plastic pipe for pressures up to 490 psi.

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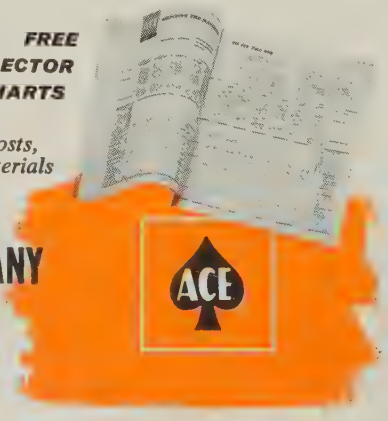

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invested in new plant and equipment by the paper and allied products industry, and total sales have doubled, from $5 billion in 1947 to over $10 billion in 1958. The industry's annual freight bill is over $1 billion. The industry provides employment to over half-a-million people, who receive more than $2 billion in wages and salaries each year. To one observer, at least, the most important single factor which will serve to promote the growth, usefulness, and stability of our industry, in 1959 and beyond, would appear to be human creativeness and ingenuity, and you, gentlemen, technically trained executives in the industry and allied fields, are precisely representative of those who will bear the responsibility and harvest the rewards of creativity in the years ahead.

Presented at the meeting of the Metropolitan District of the Empire State Section held in New York, N. Y., Jan. 13, 1959.

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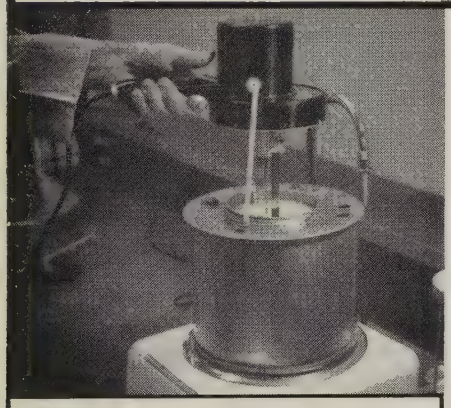

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Accounting for Pulpwood from Concentration Yards to Paper Mills

H. O. WOLCOTT

THE Southern Woodlands Department of the International Paper Co. is charged with the responsibility of supplying the ten paper mills of the Southern Kraft Division with some 5 million cords of pulpwood annually. Practically all of this wood is purchased from farmers and private land owners through independent pulpwood dealers. This pulpwood is transported to the mills on trucks, barges, and railroad cars.

For many years the pulpwood hauled into the mill yards on trucks has been unloaded by company-owned cranes, thereby quickly releasing the trucks to return to the forest for another load of wood. However, the available pulpwood within economical truck-hauling distance of the mills is not sufficient to fill the requirements on a continuous yield basis, therefore, the balance of the mills' requirements are transported principally by rail cars and a portion on barges. The handling of the rail wood and barge wood was a much slower process in that shippers' trucks were tied up for longer periods of time because it was necessary to manually unload the wood from the trucks onto the barge or rail car a stick at a time. With the ever increasing need for fresher and greater quantities of pulpwood at the lowest possible cost, the company started constructing a system of mechanized pulpwood concentration yards in 1946 to speed up flow of wood to the mills. Since the majority of the pulpwood is shipped to the mills by railroad, we will confine our discussion to rail wood concentration yards.

In setting up the system of yards, the basic plan was to select sites along a railroad strategically located as to low freight rate and lying within a network of primary and secondary roads leading into well stocked forests. A great deal of thought was given to layout of the yards in order that trucks could be scaled (measured to determine quantity of pulpwood) and unloaded as quickly as possible and to facilitate switching of rail cars. Sufficient land was acquired to provide for yard facilities mentioned and to also provide for pulpwood storage areas for emergencies. Each yard was equipped with a mobile machine for unloading and loading pulpwood and trimming up the railroad cars after they are loaded in order that none of the pulpwood sticks would protrude dangerously from the load. On most yards a crew of three to five persons perform all the necessary work in preparing and loading the wood for shipping.

We are now receiving approximately 50% of our pulpwood through the pulpwood concentration yards. The benefits derived from these yards are as follows:

1. The flow of pulpwood to our mills has been better stabilized, thereby enabling the mills to unload rail cars and barges in a more orderly fashion.
2. Freight costs have been substantially reduced.
3. Greener wood is being received at the mills, which results in better paper quality and increases yield from by-products.
4. Pulpwood production has been stimulated because many farmers and part-time woods workers are able to have their wood unloaded.
5. Extra handling charges formerly paid to shippers during emergency periods have been virtually eliminated as we are able to store wood on the yards and pick it up mechanically when needed for shipment to the mill.
6. The railroads have benefited in that the turn-around time on their equipment has been greatly decreased resulting in more pay loads with less equipment.
7. The pulpwood dealers have increased their production and reduced costs by greater hauling equipment utilization and less labor. (It was formerly necessary for laborers to accompany the driver to the loading point to assist with the unloading of the truck. The laborers formerly used for unloading now remain in the forest to cut and ready the next load for hauling to the concentration yard.)

Now that we have covered the background on these yards, we will proceed to tell you of the operations and accounting for the pulpwood from the yard to the mill. As a truck arrives on the yard with a load of wood, it is ascertained from the driver the name of the shipper and location from which wood was removed. The wood is inspected to see if it meets our mill specifications as to some of the requirements which are listed as follows:

a. The pulpwood must not be too small or too large in diameter.
b. Pulpwood should not be unduly crooked or forked.
c. Wood must be free of nails or other metal objects.
d. Pulpwood sticks must meet length requirements.
e. The wood should be as freshly cut as possible.
f. Wood must not be damaged by fire or turpentine operations, etc.

If pulpwood is not of proper size and shape, it seriously affects handling costs, pulp yield and bark cannot be satisfactorily removed. If the wood is too old and damaged, it will affect paper quality and by-products yield. Further, if wood contains metal objects and they are introduced into the mill processing equipment, it may result in serious and costly damage to the equipment. Also if metal particles manage to get through the process into the paper, quality is affected, particularly if it is punch card stock.

If the load of wood meets specifications, it is then scaled (measured) to determine the number of cords (128 cu. ft.) in the load. The scaler makes so many

H. O. WOLCOTT, Controller, Woodlands Dept., Southern Kraft Div., International Paper Co., Mobile, Ala.

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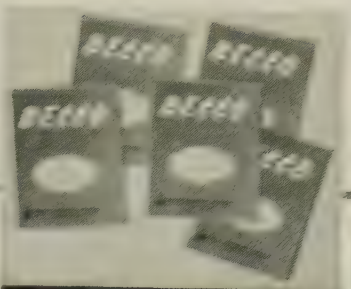

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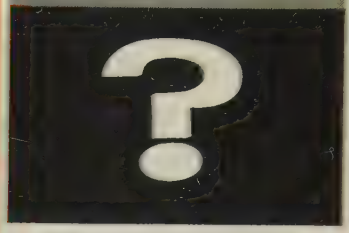

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stick length, load height, and load length measurements depending on the size and shape of the load. Taking into consideration open spots in the load and irregularities in load contour, the scaler inserts measurements onto a scale ticket. The scaler also inserts other pertinent and identifying data on the scale ticket before turning it in to the yard clerk. If the wood is to be loaded direct on the rail car, the driver is given a loading tag with the scale ticket number on it. The driver in turn gives this loading tag to the loading machine operator who writes the car initial and number on the loading tag. At the same time the machine operator inserts the scale ticket numbers from the loading tag to the machine loading report. The loading tags and the machine loading report are turned in daily to the clerk. In the event the wood is to be banked on the yard for temporary storage, the top portion of the banking tag is attached to the bundle of wood which is secured with a reusable steel strap. The bottom part of the tag is given to the yard clerk to insert cordage and file in a temporary file. During the time that the trucks are being unloaded, the scale tickets are computed to determine the amount of cordage in each load. The truck driver receives a triplicate copy of the scale ticket as he leaves the yard. For car billing, inventory, and auditing purposes a car loading report is prepared for every rail car which is loaded. The scale ticket numbers and car initials and number are obtained from the machine operator's loading reports, while the cordage is inserted on the car loading report from the scale tickets and banking tags. The original and duplicate copies of scale tickets are mailed from the yards into their respective region woodlands accounting office daily because pulpwood is purchased on the basis of weekly pulpwood purchase orders and the shippers must be paid weekly.

As soon as scale tickets are received in the woodlands regional accounting office, they are checked to the extent necessary to satisfy the office manager that the yard personnel has correctly calculated the scale tickets. Scale tickets are then separated. Original scale tickets are first sorted by species and then sorted by shippers. Original scale tickets are then posted to weekly shipper's record in numerical scale ticket sequence. The original scale tickets after they have been posted are then sorted by counties and adding machine tapes prepared for each county total to determine the number of cords removed from each county for severance tax and wood drain by counties for statistical and management purposes. The original scale tickets are then filed in individual respective wood shipper's folders, pending payment and transmittal to the wood shipper. The duplicate scale tickets are taped daily to determine total cords as a control to the daily postings on the shipper's records and for inventory purposes. The duplicate scale tickets are then filed by yards and by species in the yard inventory files. Wood settlement statements are prepared each week and include scale tickets covering receipts at the yards through Friday of the previous week as recapped on the individual shipper's records. Before checks are prepared, weekly settlement reconcilements are brought up to date. This reconciliation is prepared to reflect the beginning in ven-

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A. *Wood Concentration Point Purchases*
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See I.A.2.a. for related forms.

Book I. January, 1957

Forms Used			Location				
No.	Name	Operation	Wood Concentra. Point	District	Area	Region	Mill
175	Woodyard Scale Ticket Original Duplicate Triplicate	*Yarded Wood Yarded* Scale. See I. A. 2. a., page 1 for full explanation for completing Woodyard Scale Tickets.	D 1				
23	Banking Tag (2-Part Form)	*If Wood is Banked* Scaler attaches top part of Banking Tag to load of wood. Bottom part of Tag is given to Clerk to insert cordage and file in Temporary File, to be pulled at I. a. 1. b., Operation D-1.	D 2				

tory, plus the receipts from the yard during the settlement period less deliveries from the yard, and the ending inventory. After the reconciliation has been prepared and balanced with the tickets in the inventory file and the cordage of the reconciliation agreed with the cordage per settlement statements, then checks are prepared and settlement statements, checks, and original scale tickets are sent to the shippers.

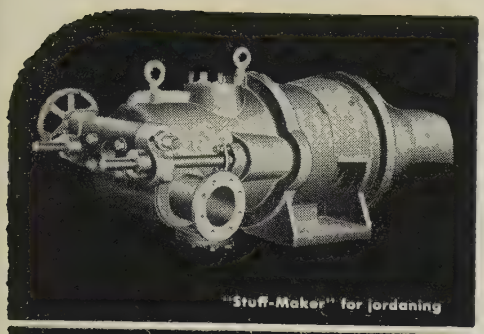
It has been attempted to thus far maintain, as nearly as possible, separation between the wood payment function and the inventory record-keeping functions at the concentration yards and in the region accounting department. We will now go back to the yards to outline the procedures for shipping wood into the mills. As stated earlier in this discussion the yard clerk prepares a car loading report from the machine operator's loading report and from banking tags if banked wood is loaded. The clerk records the car number, scale ticket number, and banking tag number by reference to the scale ticket and by pulling the bottom part of the banking tag from his yard inventory file he can determine the number of cords of wood that were loaded on the particular rail car. The clerk then prepares a bill of lading for the rail shipment, then mails the bills of lading and car loading reports to the region accounting office daily. Upon receipt of the bill of lading and car loading report in the region accounting office, they are filed in an unidentified bill of lading file pending receipt of yarded wood delivery ticket from the mill yard.

When a car of wood is received at the mill from a yard, a scaler prepares a delivery ticket for each car of wood. This ticket is a very simple form on which the scaler merely inserts date received, the rail car number, and yard number which was stenciled in certain designated places on ends of the pulpwood sticks loaded before it was released from the pulpwood concentration yard. A certain percentage of the cars received from the yards are measured as a check on the accuracy of measurements made at the concentration yards. When cars are remeasured the mill scaler prepares a check scale ticket recording thereon the car number, yard number, and measurements, etc. These check scale tickets along with the delivery tickets are sent to the region accounting office daily. Check scale tickets are calculated daily. and accumulated for a special statistical report which is sent to a woodlands technical supervisor for review. If the degree of variance between the mill scale and the yard scale is out of line, he makes necessary investigation and initiates corrective action if required. The quantity of wood received from wood concentration yards is determined as soon as possible each day as well as the quantity of wood from other sources. As soon as the total quantity of wood has been established, a daily wood report is prepared for mill inventory and management purposes, which reflects the quantity of wood received broken down as to type of wood, mode of transportation, and number of loads by rail, truck, and barge as well as the accumulative monthly figures. The daily pulpwood consumption information which is furnished by the mill is also reflected on this report.

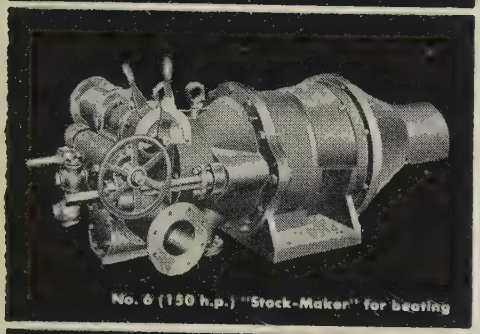
Delivery tickets are matched with the appropriate bill of lading and car loading report and gross cordage inserted on the delivery tickets. By reference to car loading report duplicate scale tickets are pulled from the appropriate yard inventory file.

On certain days during the week the Woodlands Accounting Department prepares a cordage certificate from information on delivery tickets, to each railroad for the pulpwood received at the mill from the woodyards. A separate certificate is made up for the wood received from each concentration yard. The date cars are received, car initial and number, and the gross cordage loaded on each car is shown on the certificate. On the basis of these certificates the railroads bill the Woodlands Department for freight. Since we furnish the railroads the basis for billing us freight, our records are subject to audit by railroad inspection bureaus.

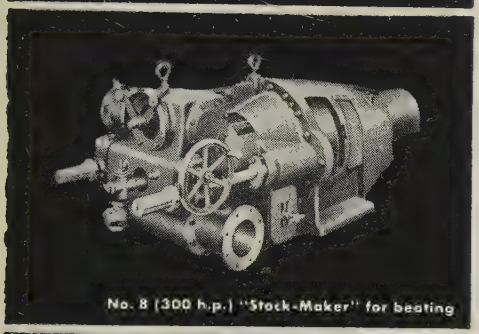
As it was initially mentioned, our Woodlands Department is a service organization to supply the mills with their pulpwood requirements. The Woodlands Department has its own accounting departments which are responsible for the accounting incidental to the acquisition and management of timberlands and the purchase and expenses in connection with the procurement of pulpwood for the mills up to the



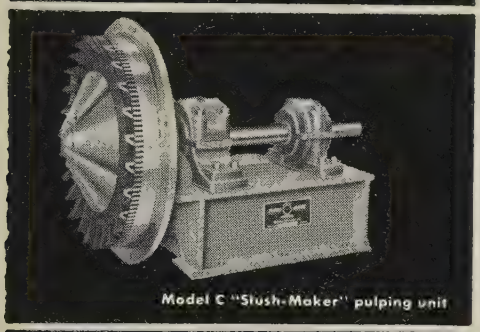
"Stuff-Maker" for jordaning



No. 6 (150 h.p.) "Stock-Maker" for beating

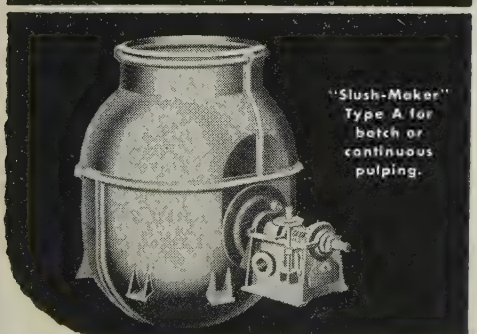


No. 8 (300 h.p.) "Stock-Maker" for beating



Model C "Slush-Maker" pulping unit

"Slush-Maker" Type D for continuous dry end pulping.



"Slush-Maker" Type A for batch or continuous pulping.

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point of unloading the wood on the mill yards. The mills account for the pulpwood from the point of unloading onto the mill yard. The Woodlands accounting departments must furnish the mills wood cost figures as soon as possible after the end of each month.

I.A.2.a. **Woodyard Scale Ticket** January, 1957

INTERNATIONAL PAPER COMPANY
SOUTHERN KRAFT DIVISION
TRUCK AND TIERED WOOD—SCALE TICKET

SHIPPER (S1) H. N. Adams

TRACK NAME (S2) E. O. McClue

TRACK IDENT. No. (S3) E. Chatham

TRUCK No. (S4)	PASS No. C-2 (S7)
TRAILER No. (S5)	DATE (S8) 9-17-56
COUNTY (S6) Washington	SCALER (S9) J. L. D.

(S10) HEIGHT MEASUREMENTS

52	54	53	55
51	56	52	57

PINE	√	H'DWOOD	
ROUGH	√	PEELED	
Green	100	OLD	

TIER MEAS.		Hgt. x Lgth.
HGT.	LGTH	3 2
5.4	14.0	2.36

STICK LENGTHS

TOTAL	AVERAGE		
(C4) 26.3	(C3) 5′3″		
5.3			
5.2			
5.3		(S17)	
5.2			
5.3			

(C1)	(S16)	(C2)
TOTAL		2.36
GROSS CORDS (C5)		3.10

DEDUCTIONS	A. D.	No. STKS.	CORDS
Sm	3″	21	
(S12)	(S13)	(S14)	(C6)

Sample Per Cent (S15)	(S22) BARGE NO.	(C7) TOT. DEDUCT'S
	(S21) SPECIE	(C8) NET CORDS 3.10

Time—4:00 pm
Miles—3
(S18) COMPUTED H. B. (C9)

(S19) Zone No. 1
T 2
(S20) Yard No. 101

Form 175 Yellow Front

Disposition of Copies
Originals —To shipper with settlement statement.
Duplicates—Filed in numerical file.
Triplicates—To driver.

I. A. 1. a.
Operation D-1, page 1

Write Scale Ticket.

Key to Abbreviations

SM	Small Wood
BT	Badly Trimmed
TF	Turpentine Faces
CTF	Charred Turpentine Faces
TFNT	Turpentine Faces, Nails and Tins
CTFNT	Charred Turpentine Faces, Nails and Tins
CW	Charred Wood
RW	Rotten and Dotty
HW	Hollow Wood
LG	Large Wood
CF	Crooked and Forked
UHDW	Undesirable Hardwood
ACW	Axe Cut Wood
AD	Average Diameter
AL	Average Length
BO	Butts Out
BTL	Back Tiers Low
BX	Box Car
C	Crooked Wood
KW	Knotty Wood
RK	Rack Car
S	Sample
SE	Sharp Ends
TW	Trashy Wood
VS	Void Spaces
OT	Old Tops

Form 175 Yellow Back

I. *Pulpwood Purchases*
A. *Wood Concentration Point Purchases*
2. *Sample Forms and Reports*
a. *Yarded Wood Yarded*

See I. A. 2. a. for forms.
See I.A.l.a. for flowchart. January, 1957

1. *Scale Ticket Issuance*
Woodyard Scale Tickets in triplicate, Form #175, will be issued by the Office Manager to the Yard Clerk as required.
2. *Preparation of Woodyard Scale Ticket, Form #175, is as follows:*
I.A.l.a.

Scaler Operations *Operation D-1, I.A.l.a., page 1*
No.

S 1. *Shipper*
Write name of dealer. Scaler writes Scale Ticket.
S 2. *Tract Name*
Name of tract, if available.
S 3. *Tract Identification No.*
Tract number, if available. Deed number will replace later.
S 4. *Truck No.*
Identification number which truck bears.
S 5. *Trailer No.*
Identification number if delivery is made by trailer.
S 6. *County*
Write county from which wood was delivered.
S 7. *Pass No.*
If banked, show Banking Tag number and number of bundles, as 17-1, is written. If direct loaded to car show designation "C" and number of bundles. "C-2" would mean loaded on Rail car in 2 bundles.
S 8. *Date*
Date of preparation of Scale Ticket.

At intervals detail cost statements are prepared for the various types of loading equipment on the yards. These statements show the yard, or yards, on which the loading equipment operated during the period covered; date equipment was purchased; the amount of fuel, tires, tubes, maintenance; and miscellaneous costs. In addition, the total hours operated during the period is shown and a unit cost per hour is calculated for each piece of equipment.

Though these wood concentration yards have to a certain extent increased clerical paper work, the savings and benefits mentioned in the early part of this paper have more than offset the additional clerical cost.

As stated earlier, reconciliations are prepared weekly to verify inventory and purchases. Closing inventory of previous week, plus cords per settlement statements, less cords per delivery tickets should equal cords per duplicate scale tickets in the yard inventory files. Postings to control records are made from settlement statements each week.

At the end of each month each concentration woodyard advises region accounting office as soon as possible number of last scale ticket and number of last bill of lading issued at the yard in the month to definitely confirm cutoff of purchases and deliveries from yard.

After this cutoff is definitely established, the region

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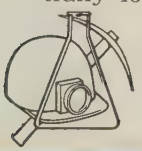
As Miners Of Sulfur Bearing Ores— We have utilized our basic position in Sulfur Chemistry to produce another product of highest purity and quality for use in the Southern Pulp and Paper Industry.

When You Need It — Our production is located in the heart of the Southern Pulp and Paper Industry which permits us to render overnight delivery service to most Southern points—also small lot shipments are available from centrally located warehouses.



Phone, Wire or Write for literature and test samples if desired.

TENNESSEE TC CORPORATION
TENNESSEE CORPORATION
617-29 Grant Building, Atlanta, Georgia

accounting departments are in a position to establish total cordage delivered to the mill during the month from concentration yards and all other sources. Once the total wood deliveries to mills is established, the mills are billed on an estimated basis for the wood which they received and insofar as the wood from concentration yards is concerned the mills are charged for the purchase cost of the wood, the freight, and concentration yard operating costs. There is very little variance between our estimated billings to the mills each month and the actual monthly costs since the majority of the costs are known with the exception of the last day or so in the month depending upon how the month breaks.

Considerable time has been devoted to the development of instructions covering our wood purchases accounting. These instructions have been flowcharted and have been of great value in training clerical personnel and have speeded up audit work, particularly when new men are making an audit of our records.

The Tables are excerpts from the instruction book which it is believed will be of interest:

1. A flowchart of the section covering procedure for accounting for wood received at concentration yards.
2. Copy of scale ticket referred to as step 1 of flowchart.
3. Portion of instructions covering preparation of above listed scale ticket.

Since the wood concentration yards are so scattered and since a great deal of money is involved in the purchase of pulpwood through these yards, skilled technicians continually spot check the yards to ascertain that scaling practices are uniform for the benefit of sellers and the company. Additionally, the regional office managers have field accountants make a physical check of pulpwood inventories on the yards from time to time.

The operating labor, loading equipment expense, yard maintenance expense, and yard overhead expense are accumulated during the month for each yard. At the end of each month cost statements are prepared for each yard giving the current month's and year-to-date cost figures. These statements also reflect type and amount of pulpwood purchased by the yard during the month and unit per cord cost for each cost item. These statements are distributed to the various levels of management down to the yard foreman. In addition to the individual yard operating cost statements, summary statements are prepared for each type of wood, i.e., pine and hardwood, by mode of transportation. These summary statements reflect a total purchase cost for all applicable yards showing this month and year-to-date figures and are distributed to levels of management above foremen level.

Released from the files of the National Association of Accountants for publication in *Tappi*.

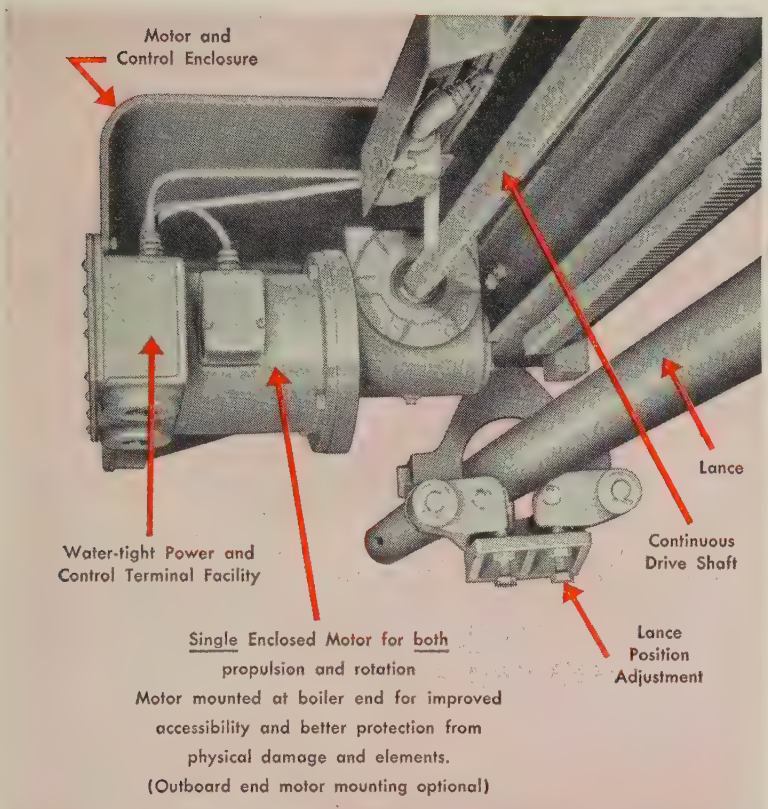
Tenth Coating Conference of the Technical Association of the Pulp and Paper Industry

Statler Hotel, Boston, Mass.
May 25–27, 1959

FRONT END Single-Motor DRIVE

another important feature of

New Diamond Series 300 IK LONG RETRACTING BLOWER



Single Enclosed Motor for both propulsion and rotation
Motor mounted at boiler end for improved accessibility and better protection from physical damage and elements.
(Outboard end motor mounting optional)

As illustrated at the left, only *one motor* is used to simultaneously propel and rotate the lance tube of the new Series 300 IK. The motor is stationary and is mounted at the boiler wall for easier accessibility and greater protection from physical damage and the elements (note the protective enclosure). This front end single-motor drive is simple and dependable. There is only *one* set of motor elements . . . *one* set of control elements . . . and *one* set of power supply facilities to operate and maintain.

Additional important features of the new Series 300 IK are listed in the panel below. Check them and you will understand why this blower is establishing a new standard of efficiency, economy and dependability in cleaning those heating surfaces that require a long retracting blower. For further information about the new Series 300 IK, ask your local Diamond office or write directly to Lancaster for Bulletin 2111AE.

OTHER ADVANTAGES OF SERIES 300 IK BLOWERS

- Backbone and Protective Cover
- Compact, Accessible Electric Power and Control Terminal Facilities
- Nozzle-Sweep-Every-Inch Cleaning Pattern
- Improved "Type A" Nozzle
- Positive Gear Carriage Drive
- Poppet Valve with Adjustable Pressure Control
- Positive Mechanically Operated Valve
- Single Point Outboard Suspension
- Oversize Lance (Step-Tapered for Extra Long Travel)
- Auxiliary Carriages for Extra Long Travel
- Designed for Quick, Easy Servicing

No other blower gives you all these advantages.

Diamond

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Taylor Instrument Companies

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with all the outstanding features of

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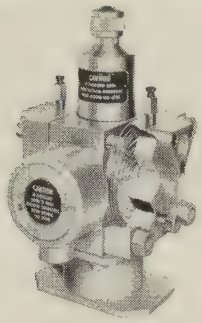
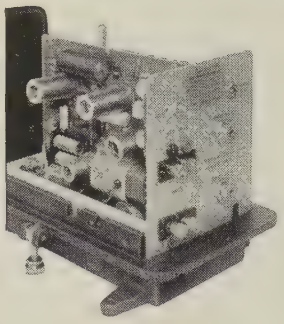
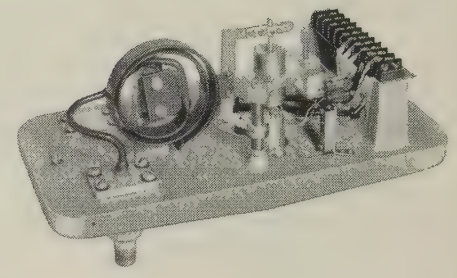


707T DP Transmitter. It provides direct conversion from differential pressure to an AC signal. No maintenance . . . insensitive to vibration . . . self-draining and venting . . . positive over-range protection to 1500 psi . . . no process fluid in contact with internal parts, double stainless diaphragm seal between process and electrical components . . . no stuffing box, no bending members, no pivots, no flexible diaphragms nor torque tube seals. No vacuum tubes, no transistors—only a simple differential transformer. Highly linear adjustable silicone damping. Perfect for all flow applications. External zero, with wide range of zero suppression. Designed for use in Class I, Group D, Division I areas.



700T Potentiometer Transmitter. Unsurpassed for sensing and transmitting Temperatures (either thermocouple or resistance elements), Load, Speed, pH, or other millivolt signals. Electronic balancing eliminates the need for slide wires, batteries, standard cells or moving parts. Continuous vernier adjustment of span or zero is simplest on the market.
Interchangeable plug-in service "cans" permit quick adaptation of one instrument for use with different primary elements. Amplifier plugs in for simple servicing. Infinite sensitivity to the input signal. Weatherproof case permits field mounting. Users consider it the finest potentiometer transmitter available.



705T Pressure Transmitter. Bourdon tube senses pressure changes and moves the core of a differential transformer to change its electrical output. A simple, extremely dependable unit, built for many years of trouble-free service. Simple span and zero adjustments. Pressure ranges from absolute to 2000 psi.

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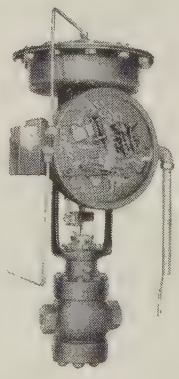

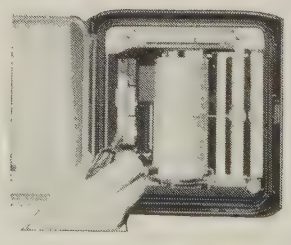

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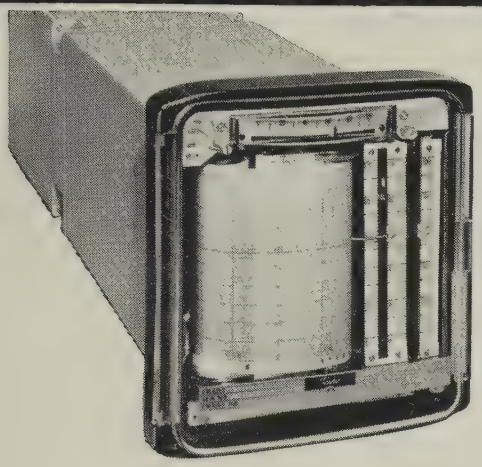
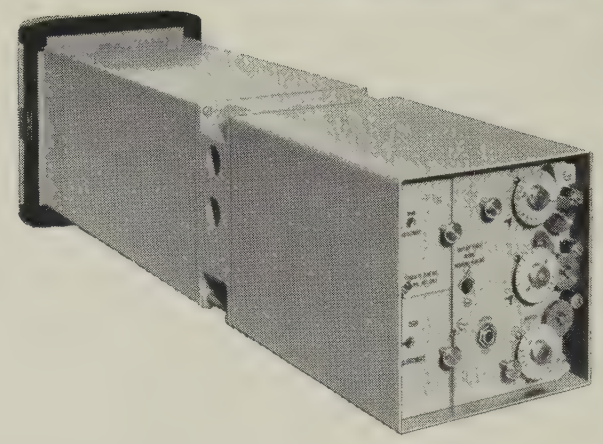


Parallels electronically all the features of the TRANSCOPE Pneumatic Recorder that have won such wide acclaim. Positive, precise pen positioning provided by actual servo-motor, hundreds of times more powerful than meter type movement. Control settings and adjustments can be made from front or rear of case. Recorder can be removed without disturbing process control. Bumpless manual-to-automatic transfer is obtained without manual matching of set point and process. Plug-in Set Point Transmitter permits uninterrupted control.

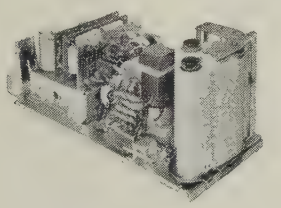
All transistorized (solid state), the 701J Recorder is unaffected by ±10% line voltage variation; thus there is no need for an expensive constant voltage source. All principal assemblies and sub-assemblies are plug-in type for flexibility and easy accessibility.

AC or DC CONTROLLER

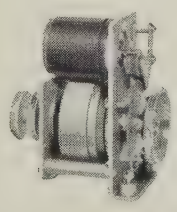


Embodies all the advantages of the most advanced control circuits. The unique diode limiter circuit permits even the two-response controllers to eliminate overpeaking on most applications. It is effective *at all times,* whether the variable is approaching control point from above or below; on changes in set point; following major process disturbances; or on start-up.

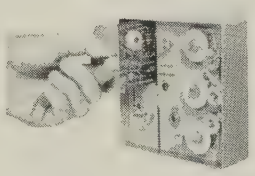
Interchangeable, plug-in assemblies permit conversion to either fast or standard reset and two-response or three-response controllers. Unparalleled rangeability makes this a universal controller. Unaffected by line voltage changes up to ±10%. Controller signal gives multiple valve operation. Output signal from 1-5 Ma feeds into any load from 0-10,000 Ohms. Plug-in assemblies: control responses, operational amplifier, AC/DC Converter, DC reference supply and controller.



2. Interchangeable Recorder Slide. Completely transistorized. Unaffected by a supply voltage change up to ±10%.



3. Powerful Servo Motor gives more precise pen positioning than ever before. More accurate records.



4. Plug-in Controller Sub-Assemblies. Printed circuit boards, mercury bottle disconnect switch.

5. Extremely Stable Controller Amplifier, utilizing latest design techniques and premium components.

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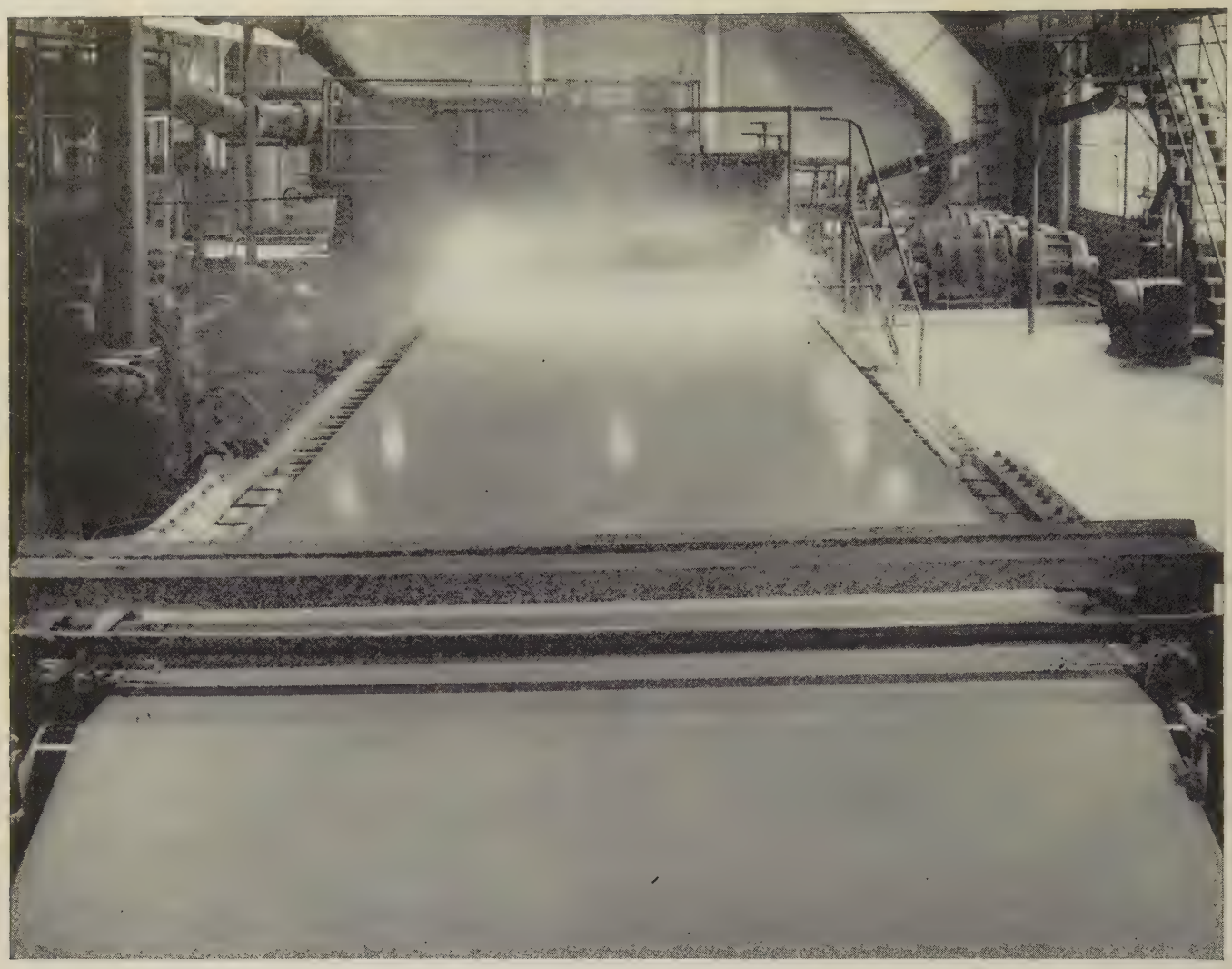

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Today's complex papermaking operations require a wide range of starches—starches specifically designed to do a particular job. You'll find that the complete starch line offered by Corn Products Company includes types for every phase of modern papermaking. These starches are available in so many varieties that *they can literally be tailor-made to suit individual requirements* and production problems of individual plants!

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*A reprint on the results of corn starch usage is available on request from our New York office.

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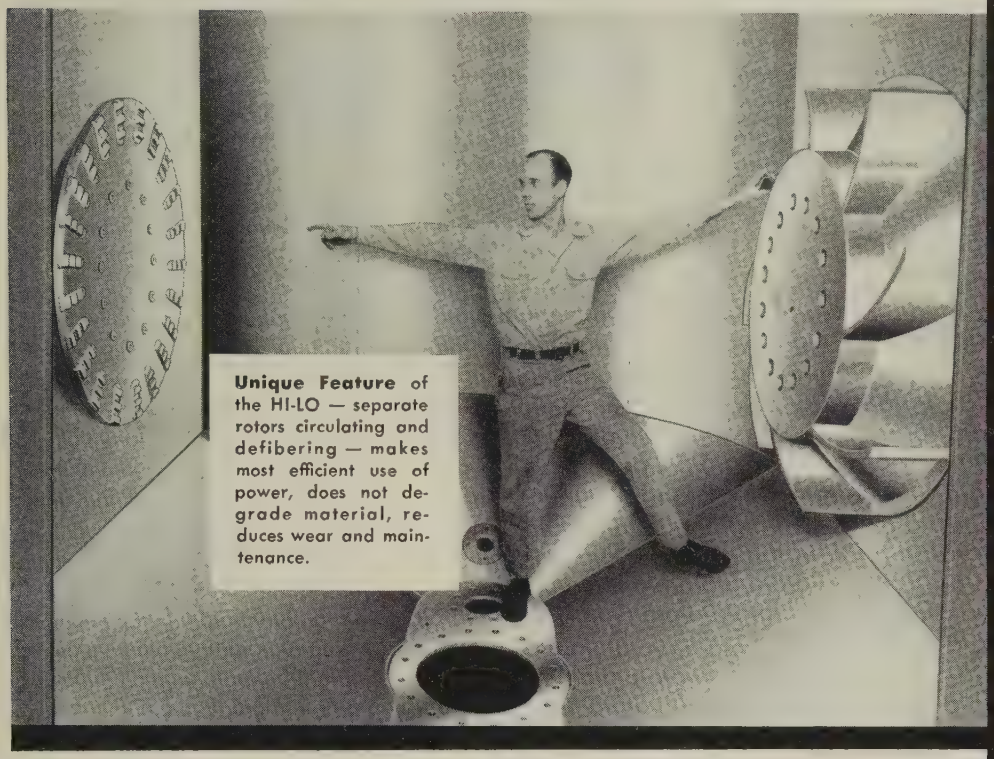
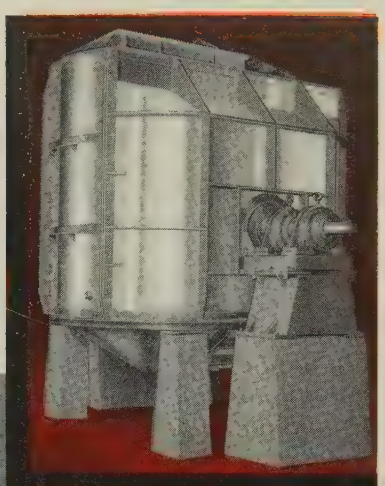


Unique Feature of the HI-LO — separate rotors circulating and defibering — makes most efficient use of power, does not degrade material, reduces wear and maintenance.



Improved tank design adjacent to the low speed rotor assures even flow of stock past the high speed defibering rotor, improves the pull-down of light broke, and greatly accelerates the initial breaking of bales.

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By introducing the new design principle — two separate rotors — the HI-LO eliminates the compromise necessary in single-rotor machines between maximum circulation and maximum speed of defibering, without excessive use of power.

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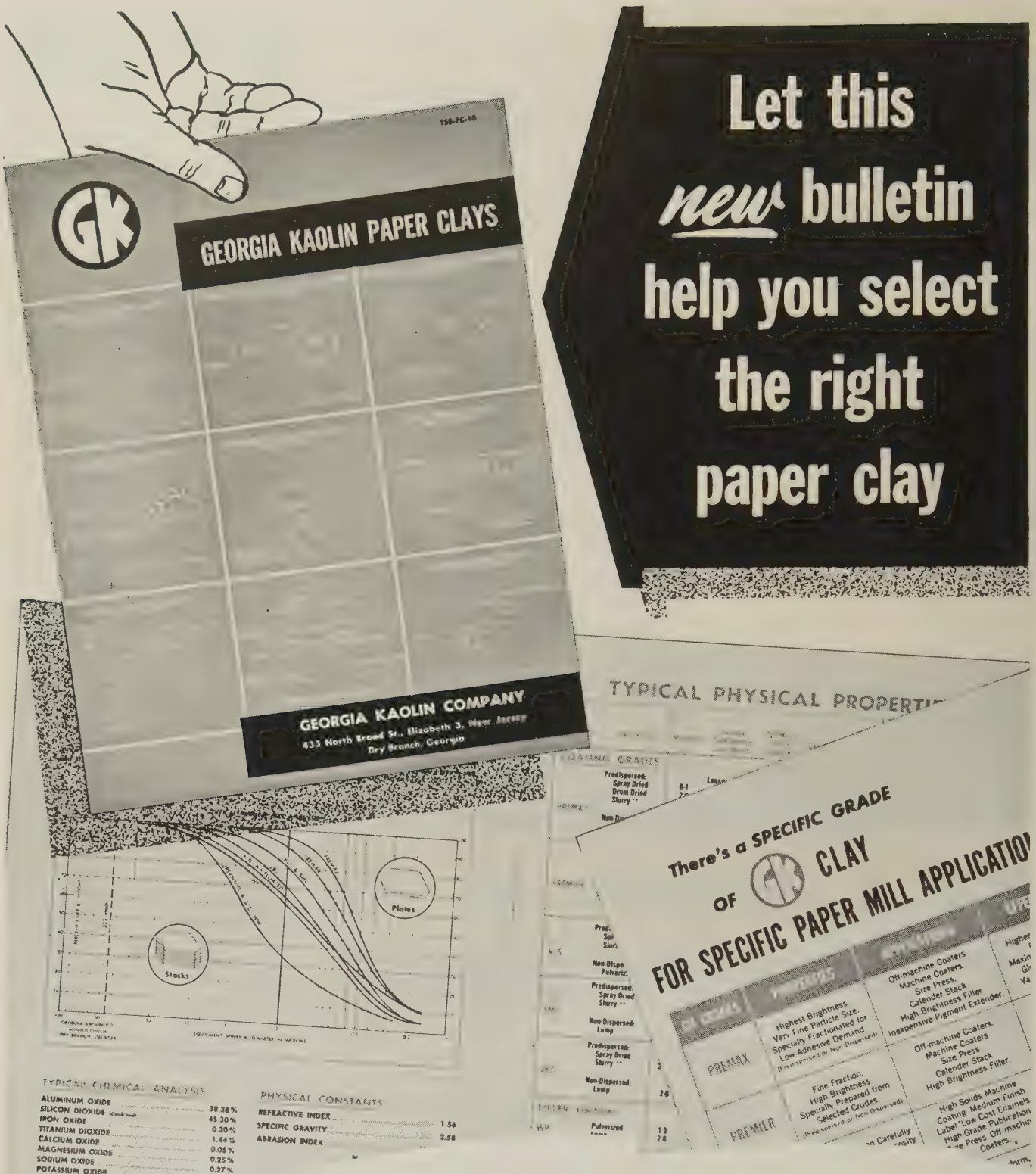

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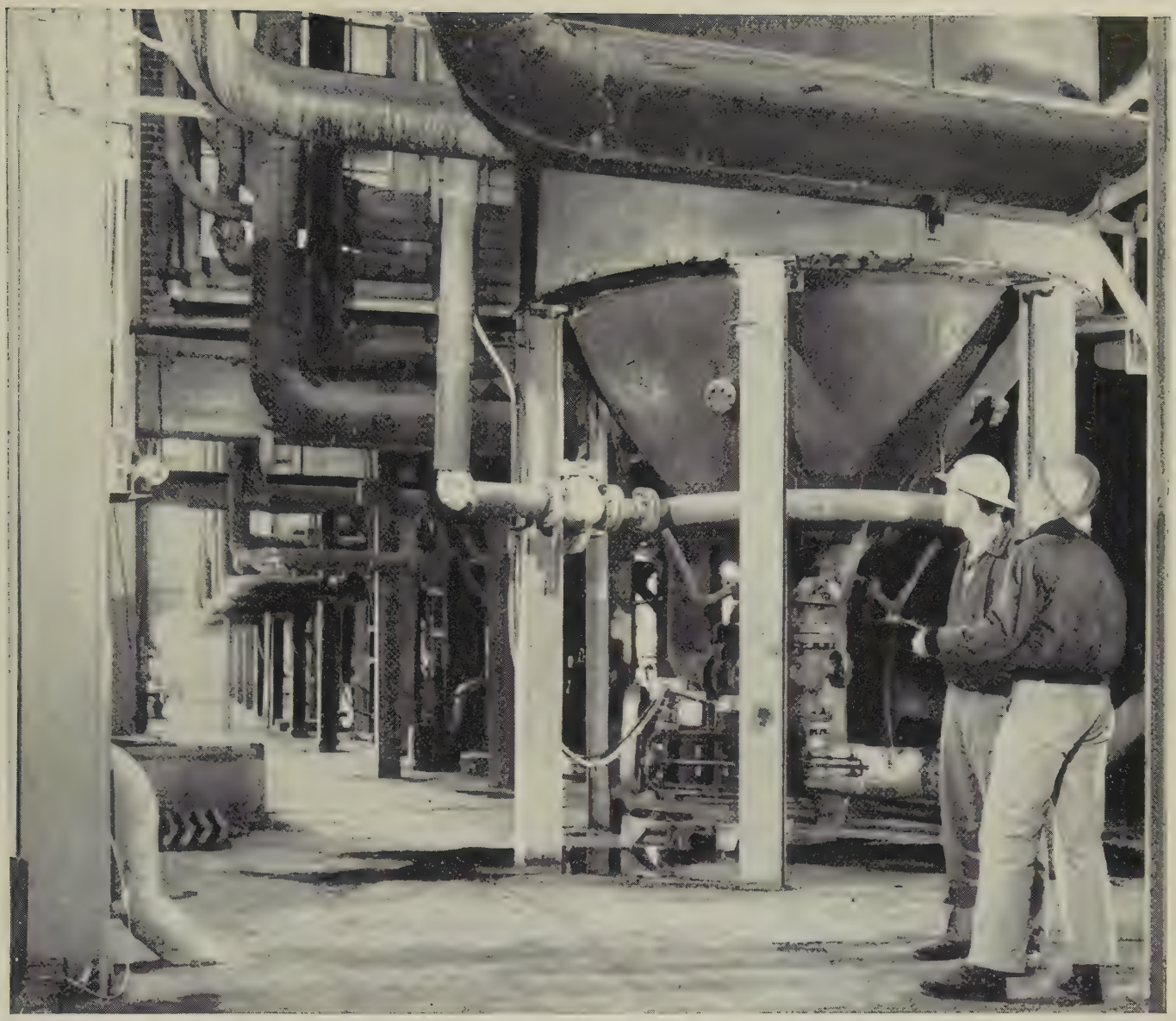

Inconel-clad digester has been in constant service since 1950 at Crossett Paper Mills. Corrosion and erosion have been checked by Inconel alloy cladding.

What's "cooking"? A solution to digester corrosion . . . Inconel cladding!

At Crossett Paper Mills, Crossett, Arkansas, corrosion was knocking mild carbon steel digesters out of service in six to seven years.

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Markets and End-Use Applications for High-Density Polyethylene-Paper Combinations

A. J. DRAGONETTE

THIS discussion will emphasize the role high-density polyethylene plays in extrusion coating.

The question has been raised—"Will high-density polyethylene coatings pay off?" A very direct question. It probes to the nerve center of business motivation which is, in a single word—profit. There is probably no greater single cause for concern on the part of business management these days than the problem of shrinking profits. Specific to the paper industry, the *Wall Street Journal*, August 6, had this comment:

> "Paper mills, whose earnings in the second quarter trailed 1957 by 15.7%, are just coming out of the summer vacation period, and the next few weeks will tell the story of what to expect as customers order for fall and winter packaging and printing needs."

Certainly it's also true that during that same period the average net income of 552 companies fell 31.9%. I suppose it might be rationalized that the pulp and paper industry therefore, did 50% better than the average of all industry. However, I am sure that in your industry as in the chemical industry, we don't kid ourselves with such statistics. I think instead, we face up to the challenge of creating better products for better profits. In evidence of this I would like to quote the October 9th *New York Times* regarding statements made by Clarence F. Smith, first vice-president of the Inland Container Corp. Mr. Smith was addressing a meeting of the Fiber Box Association. He said in effect:

> "Industry production had increased an average of 7.4% a year until 1955, but had been standing still since then. Box makers, . . . had lost about $330,000,000 in sales because of the decline in growth . . . Manufacturers would have to increase the quality of their product, develop new uses and be more alert to competition from rival forms of packaging."

It is in creating better products for better profits, that high-density polyethylene will pay off in extrusion coating. Let us, as an example, take the case of 50-lb. kraft paper selling for $180 to $190 per ton. With an additional investment of 15 lb. per ream of high-density polyethylene, that same ton of kraft sells for about $720, an upcharge of $540 on an increased material cost of $270. This is an attractive markup even after allowing a reasonable factor for labor, scrap-loss, and other expenses.

Now is the time to exploit high-density polyethylene. Availability of extrusion-coating quality resin used as a protective coating on paper has stimulated fresh interest in many potential end uses. Consumer and industrial packaging looms as the major market. Advantages inherent to high-density polyethylene-paper combinations offer opportunity to extend the use of paper in competition for new markets. These same advantages offer the opportunity to get a stronger hold on packaging end uses which have been traditionally paper markets.

For example, metal and glass containers are under steadily increasing competitive pressure from rigid plastics of the injection and blow molded type. Paper does not figure prominently in this market at present. However, a suitable coating of high-density resin will qualify paper as a candidate material for many such uses. For convincing proof of this approach we have only to remember the paper milk carton. The same opportunity for this kind of accomplishment lies in other uses. The collapsible tube is an example.

The first collapsible, fold-up metal tube was devised about a hundred years ago to hold artists' paints and keep them from drying out. Today tin, lead, aluminum, and alloys of these metals, along with plastics, are seen in daily use as containers which number over one billion units per year—worth about $40 million.

This is the pattern of raw material used for tubes.

Raw Material Used For Tubes[a]

(Million pounds)

	1940	*1945*	*1950*	*1955*
Aluminum	NA	0.8	5.0	7.2
Lead	6.0	38.0	18.5	18.0
Tin	7.7	1.2	2.2	1.3
Total	13.7	40.0	25.7	26.5

[a] Collapsible Tube Manufacturers Association.

The unit production of tubes in millions of gross was as shown here.

	1940	*1945*	*1950*	*1955*
Aluminum	0.3	0.4	2.8	3.9
Lead	0.6	3.6	1.9	2.3
Tin	2.1	0.1	0.7	0.7
Alloys	NA	1.8	1.0	0.4
Total	3.0	5.9	6.4	7.3

Certainly a steady growth in spite of rivalry from aerosol pressure cans. A good question at this point might be—what properties, in a raw material, are regarded as those most important for collapsible tube manufacture? Some of these are listed and report the opinion of the Collapsible Tube Manufacturers Association.

Required	*Desirable*
Availability	Lightweight
Flexibility	Good printing surface
Machineability	Attractive finish

A. J. DRAGONETTE, Product Manager, Packaging New Product Engineering Dept., Bakelite Co., Div. of Union Carbide Corp., 30 East 42nd Street, New York, N. Y.

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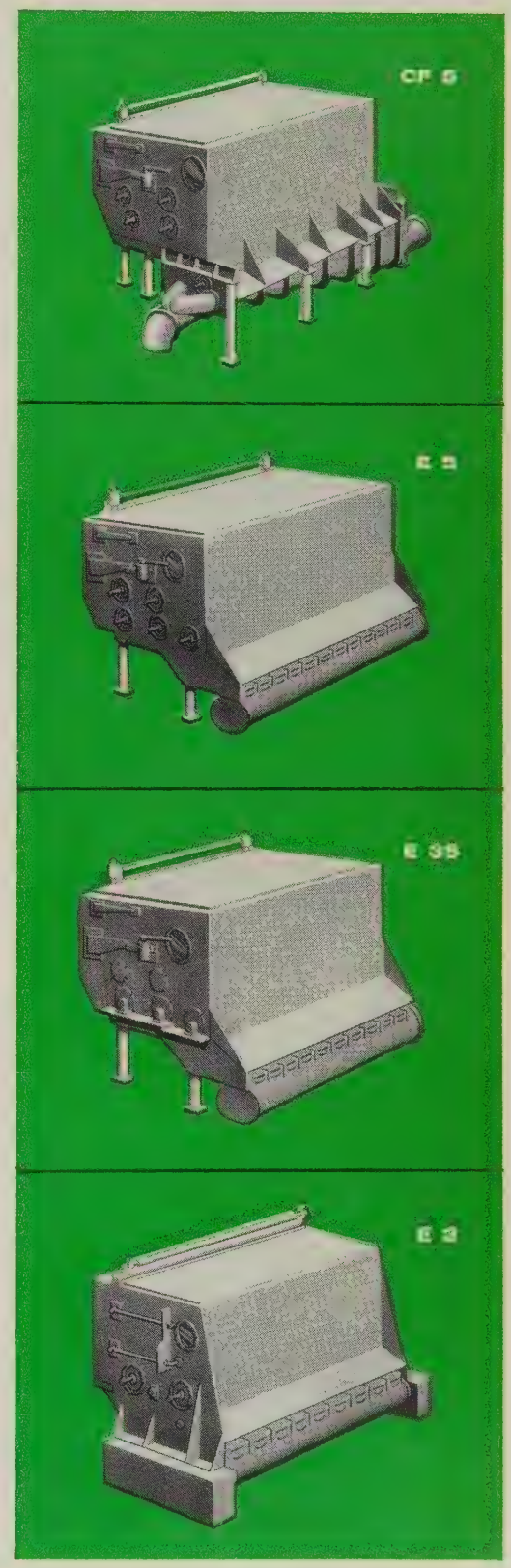

If you are troubled by any of these common problems, it will pay you to replace your obsolete inlet with a new Beloit Air-Cushioned Inlet. Beloit inlets are now available in *four* distinct types . . . suitable for every grade, speed, and price range . . . engineered to your exacting requirements. Beloit Air-Cushioned Inlets include these features: positive stock level control for optimum flow conditions • micrometer-type adjustment with flexible slice lip • simplified precision slice-adjusting mechanism • edge control • effective foam-killing showers • variable speed rectifier rolls • adjustable throat • rugged stainless steel construction • Beloit custom controls • self-cleaning design.

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Required	*Desirable*
Compatibility	Nondenting
Nonpermeability	Nonair sucking
Sealability	Sterilizable
Adaptability	
Reasonable price range	
Toxicologically acceptable	

Statistics showing end-use pattern of collapsible tubes are shown here as reported by the Collapsible Tube Manufacturers Association.

1955 Shipments of Collapsible Metal Tubes

(Million gross)

Dentifrices	3.9
Pharmaceutical & medicinal	1.3
Household & industrial	1.1
Cosmetics	0.6
Shave cream	0.4
Food products	0.005 (720,000 thousand)
Total	7.3

The relative cost of tubes is illustrated in this table.

Relative Cost of Tubes

Material	*Sp. gr.*	*Cost, cents/lb.*	*Pounds to make 100 tubes*	*Material cost, cents/tube*
Aluminum	2.7	27+	1.3	0.36+
Lead	11.3	16	6.5	1.04
Tin	7.3	104	3.5	3.64

The estimated market for tubes, with projection to year 1975 is shown here.

Estimated Markets for Tubes—End Uses

(Million gross)

	1955	*1960*	*1965*	*1975*
Dentrifrices	3.9	4.9	5.0	5.8
Pharmaceutical & medicinal	1.3	1.7	2.0	2.3
Household & industrial	1.1	1.6	1.9	2.0
Cosmetics	0.6	0.9	0.9	1.0
Shave cream	0.4	0.4	0.1	0.05
Food products	0.005	0.003	0.1	0.2
Total	7.3	9.5	10.0	11.4

As a point of interest, government, industry and trade association statistics indicate this end-use pattern for metal cans.

1955 Shipments of Consumer-Type Metal Cans

End use	*Billions of units*[a]
Fruits, vegetables, juices	13.0
Dairy products	2.6
Coffee	1.6
Meat	1.2
Lard and shortening	1.0
Fish	1.0
All other food (e.g., soup, baby food)	3.8
Beer	6.3
Soft drinks	0.3
Pet foods	1.3
Oil	2.5
All other	4.6
Total	39.2

[a] Equivalent of no. 2 cans.

A good question here might be—How many of these uses are vulnerable to displacement by less costly containers?

Well, every time you read captions such as this one from the *Wall Street Journal*, September 22, "U. S. steel to hike tin plate prices, others expected to follow; can firms indicate they'll pass rise along" "Increase averaging 3.5% is effective November 1."

I repeat, every time you read captions like this it means more competitive pressure on the use of tin cans from other materials. And a few more traditional tin can markets will topple and become vulnerable. Let's underline some that might be vulnerable today.

	Billion units
Fruits, vegetables, juices	13.0
Dairy products	2.6
Coffee	1.6
Lard & shortening	1.0

The next table shows a similar end-use pattern for glass containers.

1955 Shipments Of Consumer-Type New Glass Containers

End use	*Billions of units*
Food	7.0
Medicinal	2.9
Beer, nonreturnable	1.2
Beer, returnable	0.4
Soft drink, nonreturnable	0.2
Soft drink, returnable	1.2
Household and industrial	1.7
Toiletries and cosmetics	1.7
Dairy products	0.4
Wines	0.6
Liquors	1.3
Others	0.4
Total	19.0

I think there is exciting potential for paper–high-density polyethylene combinations in such new concepts of fabrication. Accomplishing these will obviously present challenging problems to be solved. However, the concepts are sound and the basic approach is practical. The markets are large and fast-growing, and, this makes for a better than average profit situation.

There are other markets where paper–high-density polyethylene combinations offer possibility of developing practical end uses. Moisture protection and grease resistance of high-density polyethylene has been widely publicized. But improved abrasion resistance, protection from scuffing and snagging, emerges as an important performance advantage meaningful to consumer and industrial packaging engineers. Bags, cartons, and liners can make good use of this unique performance characteristic.

Low friction, high surface hardness and low abrasion weight loss characterize high-density polyethylene coatings. For example, M. A. Marcucci (*1*) reported an abrasion weight loss of only 0.0015 g. as a result of his work studying friction and abrasion characteristics of plastics materials.

Shake table tests have aptly demonstrated the practical utility of good abrasion resistance and low surface friction. The good performance in this respect suggests the use of high-density polyethylene coatings on cartons for fine furniture and appliances. The low abrasion weight loss indicates that adequate

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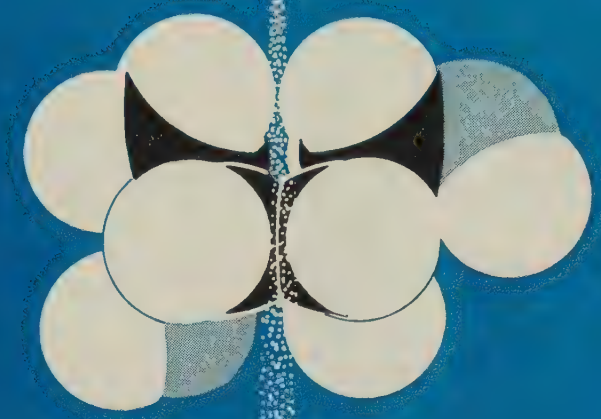

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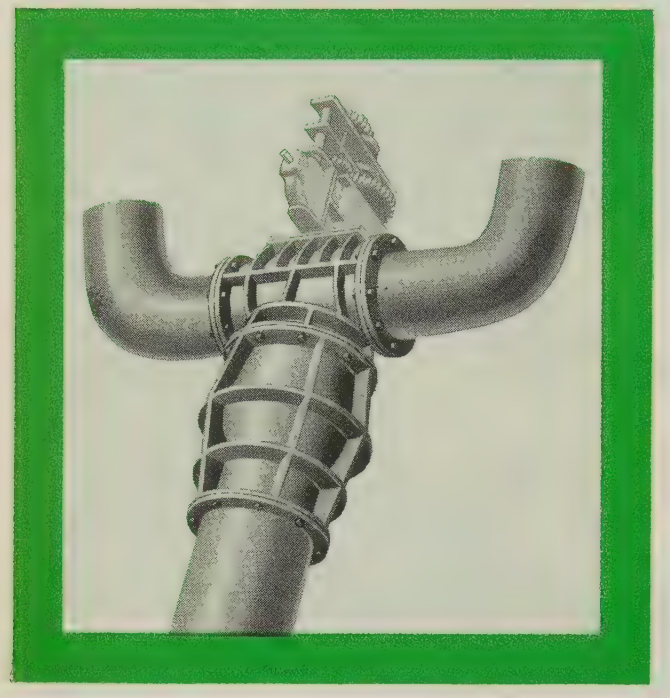

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Beloit streamflow valves are designed *specifically* for controlling paper machine water rates. Throttling is accomplished with a central pear-shaped plug, the required flow passing smoothly around the plug. Result: uniform discharge to headbox without pulsations, eddies, or lumps! Engineering features include: positive mechanical positioning—no "floating" or "hunting" • wide gallonage range with minimum head loss • self-cleaning design • air-motor operator • valve position indicator for quick setting • heavy-duty stainless steel construction • simple controls.

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protection can be obtained with relatively light, economical coating weights.

This quality of good abrasion resistance has attracted the attention of the brewing and bottling industry. The possibility of high-density polyethylene coated board for the construction of carrying cases has been greatly stimulated. The objective in this example is a low cost, durable, lightweight carrying case. The case must withstand the abuse of several trip exposures and be readily cleaned—preferably by washing. This example is not pie in the sky hypothesis—people in the brewing and bottling industry are hard at work in a serious study of materials which will give them the kind of performance for which they are looking. Low cost paperboard with a durable, economical coating of high-density polyethylene is a ranking candidate for the job.

There is another end use in which the hard surface and abrasion resistance of high-density polyethylene coatings pay off. This one is more subtle than those we have discussed. Waxed glassine paper is certainly a workhorse in the specialty paper field. These papers have been described as the "wonder papers for protective packaging." And it is true—some of the protective properties which are built into glassine paper by virtue of waxing, laminating, and lacquer coating are astounding. The performance of glassine in its role of protective packaging is a credit to the resourcefulness of your industry. But progress, and the evolution of better things for higher living standards, make the benefits to be derived as the proper reward for resourcefulness shortlived if advantages are not jealously guarded.

For example—the water vapor transmission of 25-lb. waxed glassine, 4 lb. wax, is reported to be 0.20 to 0.40 g. per 100 sq. in. per conditions of the General Foods test. However, when creased, the permeability rate jumps to 2.0 to 5.0 g. This information has been published by the Glassine and Greaseproof Manufacturers Association. The moisture vapor transmission of 1-mil film of 0.950 density polyethylene is 0.48, 0.960 density film has a permeability rating of 0.30. These permeability ratings are not changed by creasing and flexing. Of course, the point of these comparisons is that in high-density polyethylene resin there is possibility of imparting to your "wonder papers for protective packaging" a significant improvement of flexibility. By this improvement you get a stronger hold on traditional markets which are the envy of cellophane, aluminum foil, and plastics film manufacturers.

This example of how high-density polyethylene pays off also carries a bonus benefit with it. John F. Helms in his paper "Plastic Coatings and Films for the Paper Industry" said, "Surface friction is probably the greatest difficulty experienced with (low-density) polyethylene. Paper converters desire a resin with greater slip to improve performance on high speed packaging machines." Low surface friction is the bonus benefit of 0.950 and 0.960 density polyethylene on glassine and similar specialty papers. In his study "Friction and Abrasion Characteristics of Plastics Materials," Marcucci (*1*) reported high-density polyethylene to have the lowest friction factor and lowest abrasion weight loss of the 11 materials studied.

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One more newspaper caption in a recent edition of the *Wall Street Journal* held this clue to another possibility of how high-density polyethylene extrusion coatings can pay off. The caption said this: "Prices of fabrics for car interiors are increased" "Mills expect further rise soon. . ."

About 50 to 60% of these fabrics are coated with plastics for use in upholstery, door panels, and head liners. The rest go into a miscellaneous variety of industrial products. Auto seat upholstery is not the consideration here. But surely polyethylene extrusion coated paper products can be considered candidate materials for door panels, head liners, and rear deck liners. In this example also, the rising cost of fabrics increases the competitive pressure on the traditional material. High-density polyethylene, by virtue of its abrasion resistance, protection from scuffing and snagging, contributes greatly to the possibility of successfully competing with coated fabrics in auto uses. The economic advantage of high-density polyethylene–paper combinations would be great and very attractive to the cost-sensitive auto industry.

We have discussed new end-use concepts of paper–high-density polyethylene; concepts which offer opportunity to expand the use of paper in profitable new end uses. Now let's look at some of the more prosaic end uses where paper already holds a dominant position. Let's consider how high-density polyethylene can help you get a stronger hold on these traditional end uses. The improved functional properties of paper-high-density polyethylene are well enumerated and have been well advertised. However, relatively slow heat-sealing speeds have plagued the use of polyethylene coated board and paper in carton and folding box production. Now, as glue sealing on conventional cartoning equipment becomes more widely practiced, there is new interest and enthusiasm for carton and folding box uses. An excerpt from *Food Processing*, May, 1958, said this: "Polyethylene coated cartons provide all the advantages of a polyethylene liner at low cost. Only 1 mil thickness of coating gives adequate protection against grease and water penetration in packaging frozen foods, bakery products and candy."

There is great significance hidden in this comment. For example, it is no secret that the frozen food industry is ready for a single wall box—no liner, no wrapper. The objective is economy with no sacrifice in protection. *Modern Packaging*, March, 1958, reported a move on the part of Gorton's of Gloucester to pack frozen fish sticks in a single wall box that obviates both liner and overwrap. The box has a built in tear strip. The package is being test marketed in the Chicago area. (The board is 15-pt. two side waxed, solid sulphate.)

The relatively poor moisture barrier of creased, waxed board may be the vulnerable spot of the new package. An economical coating of high-density polyethylene offers more confident protection. Now, by taking advantage of glue sealing—and conventional cartoning—such polyethylene-paper combinations can be readily exploited.

In the ethical drug field, as in the frozen food field, there is live interest in better, less expensive packaging. For example, the common aspirin tablet is put in a glass bottle, labeled front and back, and given a screw-cap closure. The bottle goes into a paper carton along with a stuffer. The carton is printed all-around. This is traditional ethical drug packaging, highly respected and highly effective. But as time and progress and rising material costs swallow more of the profit on such drugs as aspirin tablets, there is new interest in cost reducing packages. And this interest leads to the possibility of new concepts of packaging in fields even where tradition is strong. There is interest in eliminating the glass bottle in packaging aspirin and similar tablets. A single wall box with a suitable coating of high-density polyethylene to provide adequate moisture protection is of interest. There is room for original design of such a box. Perhaps a flip top—or a pour spout—to minimize the problem of opening, dispensing, and storage.

The need for protection of sugar-coated cereal foods is well documented. Moisture pickup or loss is a hazard of shelf storage. In laboratory tests simulating typical storage conditions, sugar-coated cereal packed in a high-density polyethylene-paper box "kept" better than that packed in the presently used commercial package, which is a liner bag made of foil/pouch paper/wax laminate, in a carton. Brown and serve rolls have been tested in the same way with results favorable to the single-wall box. Salted crackers and "snacks" were test packed with equally favorable results.

This discussion would not be complete without some attention given to the current market for multiwall bags. Statistics for year 1957 show that a grand total of 2.75 billion kraft, multiwall bags were produced. The statistics show that packaging 11 end-use products accounts for 60% of all multiwall bags used. A breakdown of these 11 major end uses is shown here.

Major End Uses for Multiwall Bags

Product packaged	*Million bags*	*Per cent of total*	*Per cent accumulated*
Fertilizers	384	14.0%	14%
Livestock & poultry feeds	376	13.7	28
Portland cement	276	10.0	38
Sugar	146	5.3	43
Wheat flour	140	5.1	48
Prepared masonry cement	96	3.5	52
Clay & talc	90	3.3	55
Limestone	82	3.0	58
Potatoes	76	2.8	61

Source: Paper Shipping Sack Manufacturers Association.

The point of this example is, how can the total use of paper shipping sacks be further enlarged? Or—how can a stronger hold be clamped on these traditional paper markets? I believe the answers to both these questions are still another demonstration of how high-density polyethylene coatings can pay off.

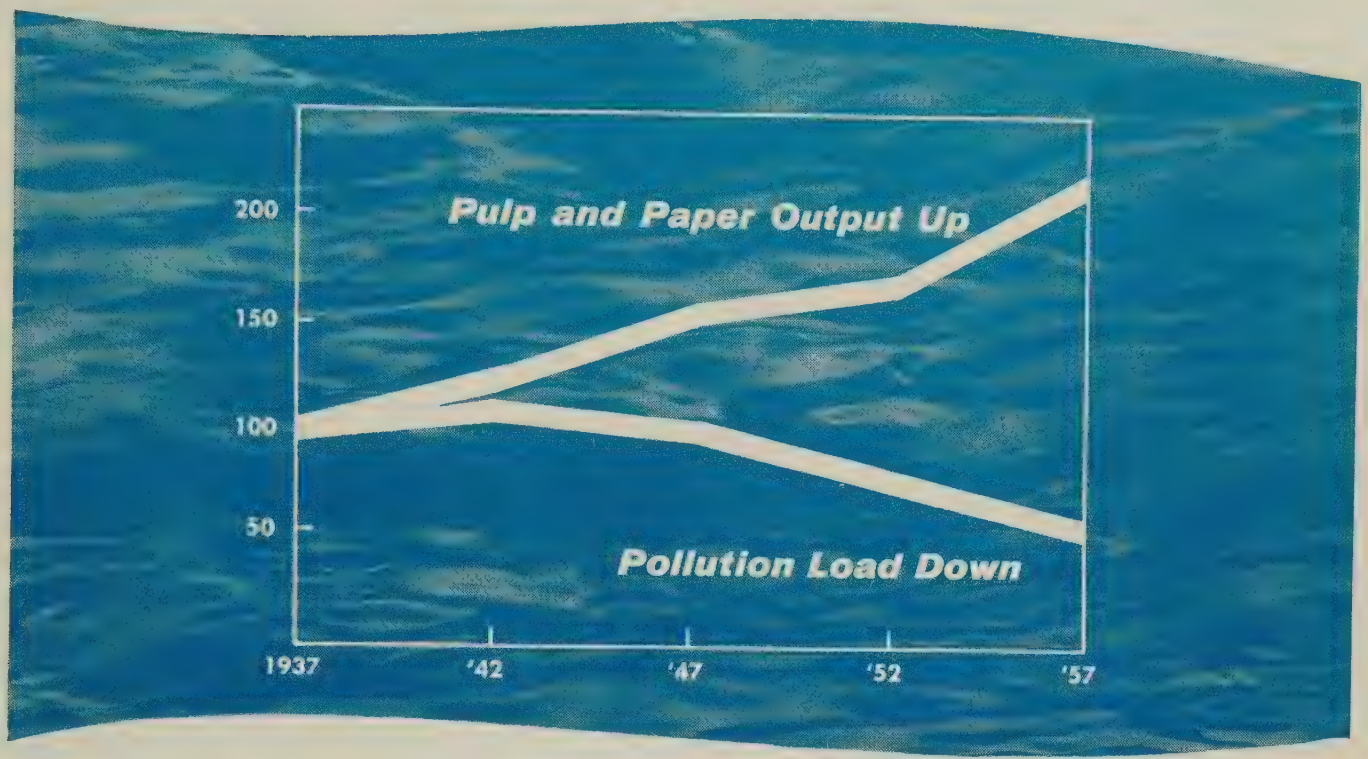
First—how can the total market be enlarged? Well, a clue to that answer may be hidden in these statistics:

	Million bags	*Per cent of total*
Bags containing a moisture barrier polyethylene–low-density	65	2.4
Asphalt	385	14.0
Total	450	16.4
Bags with no moisture barrier	2300	83.6

Source: Paper Shipping Sack Manufacturers Association.

Reduce filler and fiber loss

. . . minimize stream pollution



Source: National Council for Stream Improvement (of the Pulp, Paper, and Paperboard Industry).

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Interpreting these statistics then would indicate that less than one fifth of bag production is going in to uses requiring any moisture protection. In other words—only the very thick cream has been skimmed off the moistureproof bag market. How much can the moistureproof bag market be expanded with the use of high-density polyethylene coating? Not at the expense of present paper bag markets, but by making inroads on nonpaper moistureproof shipping containers. This would seem to be a very potent market for you to develop.

Next—how can a stronger hold be clamped on traditional paper bag markets? Recent events offer a clue to this one. It is no secret that the concept of a plastic shipping sack is strongly being promoted. And it is no secret that the interest in some of the 11 major paper bag end uses is developing. Let's underline some of these.

Major End Uses for Multiwall Bags

	Bags, MM	*Total, %*	*Accumulated, %*
Fertilizers	384	14.0	14.0
Livestock & poultry feeds	376	13.7	27.7
Wheat flour	140	5.1	32.8

Obviously, the point of this interpretation is not to threaten you with the loss of a large part of an important market. But to suggest that one way of clamping a stronger hold on that market is by upgrading the paper bag for better performance. This can be done by the use of relatively lightweight, economical extrusion coating of high-density polyethylene, assuring a level of protective properties competitive with those offered by a heavy gage plastic sack. There will be other attacks on this large paper market currently using some 826 thousand tons of paper. The security provided by an improved product will do much to discourage the antagonists.

To conclude this rundown I would emphasize this comment: high-density polyethylene–paper combinations have stimulated high expectation from, and interested evaluation of, such products for use in consumer and industrial packaging. Now is the time to exploit the potential for such combinations.

This brief discussion delineates growing trends toward the development of end uses in large volume markets. High-density polyethylene paper combinations offer good possibility as candidate materials in these markets. Your interest and your effort will be the essential ingredient in the complex. Polyethylene resin suppliers will welcome an opportunity to work with you individually and as an industry toward the development of profitable high-density polyethylene–paper products for use in large volume markets.

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Presented at the Thirteenth Plastics-Paper Conference of the Technical Association of the Pulp and Paper Industry, Springfield, Mass., Oct. 20–22, 1958.

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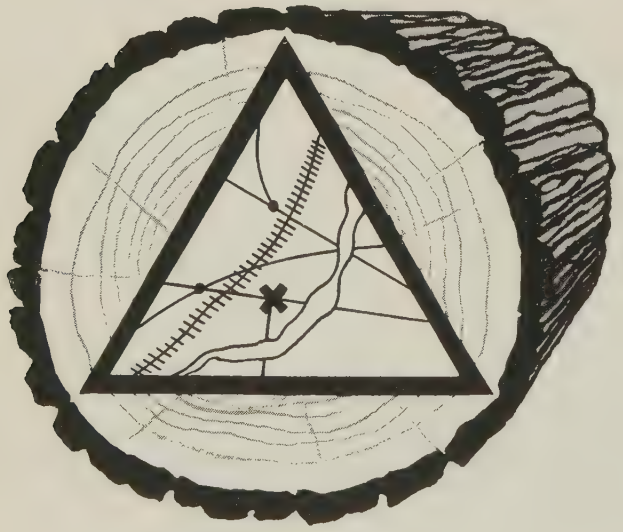

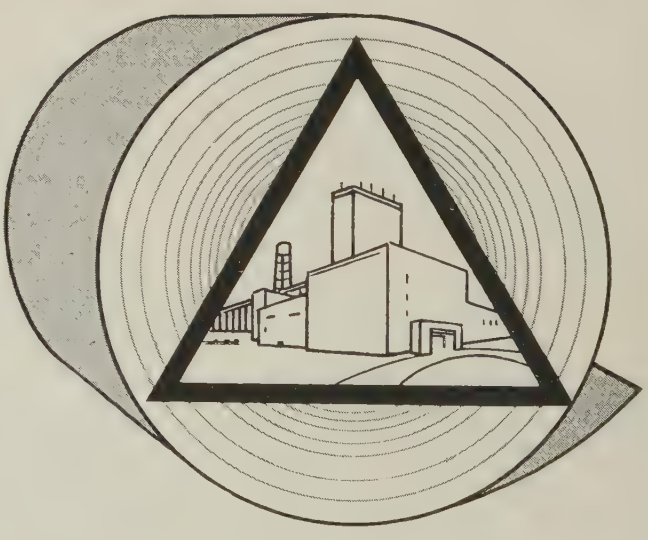

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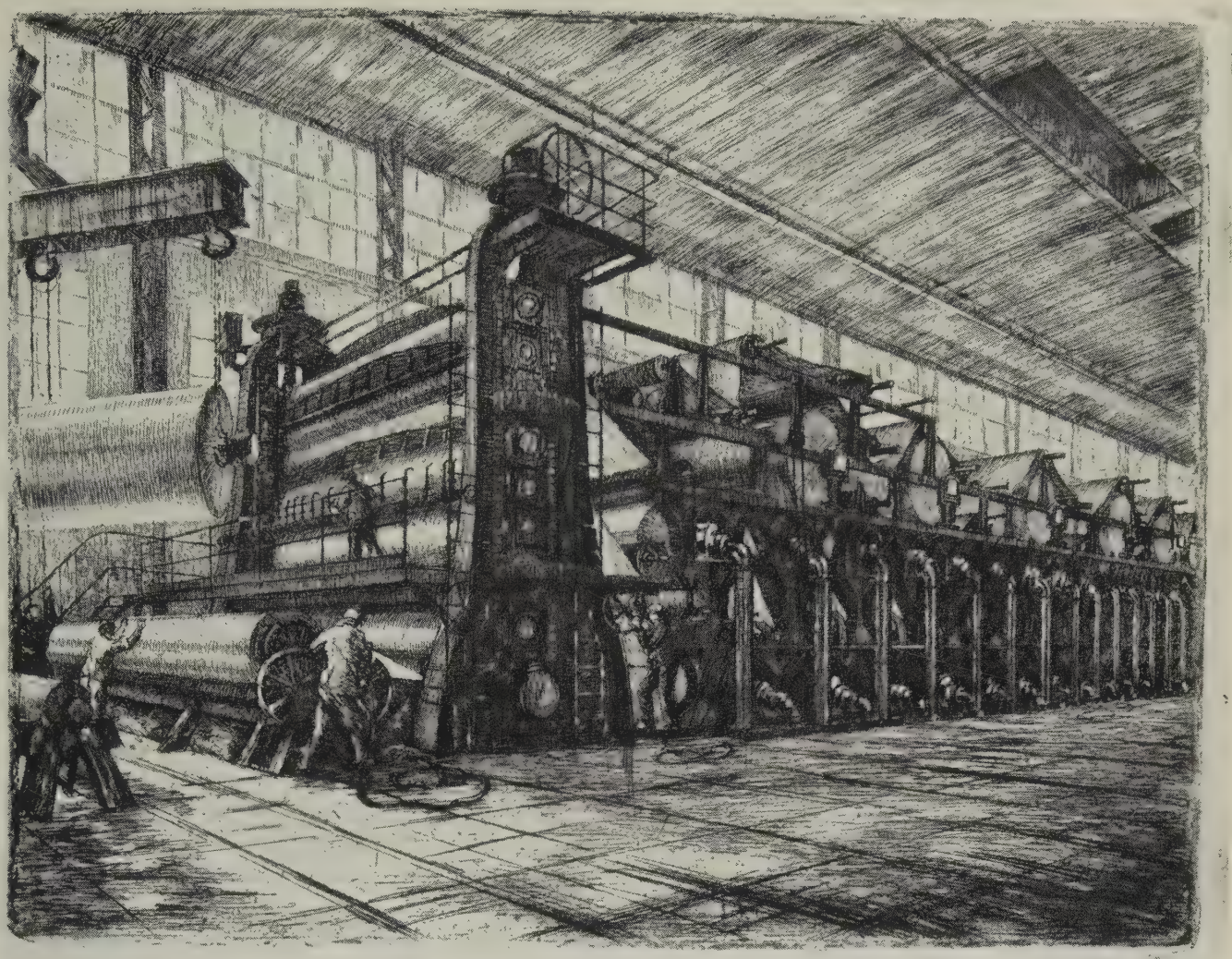

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REPORTS AND DISCUSSIONS

Presented at the National and Regional Conferences

Condensations of Annual Meeting Papers

The following are condensations of a number of the papers to be presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959. The papers will be published in full in subsequent issues of *Tappi*.

Dissolving Pulps Session I

A-1. The Spinning of Rayon Yarn as Related to Its Structure and Properties, W. A. Sisson, American Viscose Corp., Marcus Hook, Pa.

A brief discussion is given of the various ways in which the properties of rayon can be altered. It is pointed out that the major improvements in rayon tire cord have come through modification of the fine structure (orientation and crystallinity).

The various reactions which take place during the spinning of a rayon filament and how they affect the fine structure are discussed next in some detail.

The idealized fine structure for building both strength and fatigue into a rayon tire yarn is described and the approach to obtaining this structure through modification of the spinning process is outlined.

The recent improvements in rayon tire yarn are sketched and these improvements related to the changes in fine structure which have resulted from modification of the spinning process.

A-2. Some Studies in Connection with the Spinning of High High Tenacity Rayon from 100% Wood Pulp, B. B. Mithel, W. R. Saxton, J. S. Morgan, and J. Witkamp, Industrial Cellulose Research Ltd., Hawkesbury, Ont., Canada.

Investigations were carried out on the influence of zinc sulphate in the spinbath, and modifier and sodium trithiocarbonate in the viscose, on the rates of neutralization and regeneration and water swelling. The modifiers studied were cyclohexylamine and Carbowax 1500 (polyethylene oxide—molecular weight 1500).

The effect of modifiers on the regeneration rate of viscose was clearly shown by measuring the xanthate content of the partially regenerated yarn at various distances from the spinneret. Modifiers retarded the initial regeneration, presumably due to a slower neutralization, but it then became faster and after a certain point regeneration was more complete, i.e., xanthate sulphur level of the yarn was lower than in yarns made from unmodified viscose.

Zinc sulphate was shown to be a prerequisite for the action of modifiers. It was shown that even without modifiers in the viscose, zinc was effective in slowing the rate of regeneration; however, it did not delay neutralization of the caustic.

Sodium trithiocarbonate also tended to slow down xanthate decomposition but in the absence of zinc in the spinbath was without effect.

Gel swelling of partially regenerated yarn was shown to be dependent on the state of regeneration, the highest values being obtained at the highest xanthate sulphur contents. Modifiers significantly lowered gel swelling for a given state of regeneration.

A-3. Characteristics and Performance of Rayon Tire Cords, M. W. Wilson, The B. F. Goodrich Tire Co., Akron, Ohio.

Rayon tire cord characteristics that one can observe in the laboratory are first discussed and are then connected with tire performance. Effects of improving tensile strength are considered and the methods of measuring fatigue resistance are reviewed. Particular attention is given to the characteristics that are related to the interaction of rayon tire cords with water. Thus, shrinkage, penetration by adhesive, effect of wetting on tensile strength, elongation, and resiliency are covered. Factors involved in improving cord tensile strength and resiliency are examined. Considerable attention is paid to all factors affecting adhesion and a mechanism of resorcinol-formaldehyde-latex adhesion is presented.

Forest Biology Session I

B-1. What Are the Wood Properties Required by the Paper Industry in Trees of the Future?, H. Dadswell, A. J. Watson, and J. W. P. Nicholls, Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia.

Reference is made to an earlier paper in which the evidence relating wood qualities to pulp strength properties was reviewed and discussed. At that time it was suggested that the trees of the future should have (1) higher than present average fiber length for the species, (2) thin cell walls, (3) basic density lower than present average for the species, (4) cellulose content higher than present average for the species, (5) low extractive content, and (6) a growth rate as rapid as the economics of plantation management allows. Although these suggestions were based on the knowledge available at the time it was concluded that further information was desirable.

Therefore work has been carried out to determine the separate effects of cell length, cell wall thickness, pentosan content, and lignin content, in each case keeping all other factors constant. By this means the marked increase in tearing strength with increase in cell length has been established; the effect of cell wall thickness on pulp strength properties other than tear has been further emphasized; a wide range of pentosan content in hardwoods (between 7 and 15%) can be tolerated without loss of pulp strength although with reduction in yield at the lower values; for best pulp strength complete elimination of lignin is highly desirable. In addition it has been shown that in the softwoods and hardwoods investigated the cellulose content (Cross & Bevan) increases through successive growth rings from the pith becoming more-or-less constant after 6–8 years of growth; also that in different trees of the species, the cellulose content varies markedly some trees having almost 10% more than others. It has therefore been reiterated that cell length which is correlated with cellulose content, and basic density which is a very good index of cell wall thickness are characteristics that have to be considered in tree breeding work. A method of determining the wood characteristics of those trees selected by foresters as possible parents has been described briefly and examples given of the way each tree can be assessed in relation to average and extremes.

B-2. Relationships Between Wood Density and Other Wood and Paper Properties, L. A. Hiett, W. L. Thornburg, and K. A. Zachariasen, Buckeye Cellulose Corp., Memphis, Tenn.

In connection with a tree improvement program the effects of variations in wood density within and among slash pine trees have been studied. Within trees, variations in wood density are accompanied by variations in springwood-summer-wood ratio, pentosans content of wood and pulp, and alpha-cellulose content of pulp. Between trees none of the above properties appear to vary consistently with wood density, but between-tree variations in wood density are indicated to be related to changes in the cross-sectional dimensions of both the springwood cells and the summerwood cells. Variations in paper strength properties with wood density variations within a tree are greater than those caused by wood density variations between trees.

Due to the limited variation in wood density found among slash pine trees it is concluded that wood density should be considered a factor in judging superior trees only to the extent that it contributes to greater pulp yield.

Additional criteria for judging the pulp quality potential of slash pine trees are suggested.

B-3. Core or Juvenile Wood of Loblolly and Slash Pine Trees, B. J. Zobel, C. Webb, and F. Henson, North Carolina State College, Raleigh, N. C.

Research is reported on characteristics of core wood, within a tree and among trees. This research was carried out in 1957 and 1958 in a six-state territory, mainly in the Carolinas and adjoining states. The general concept of core (juvenile) and other (mature) wood is discussed and practical uses of the information on core wood are considered.

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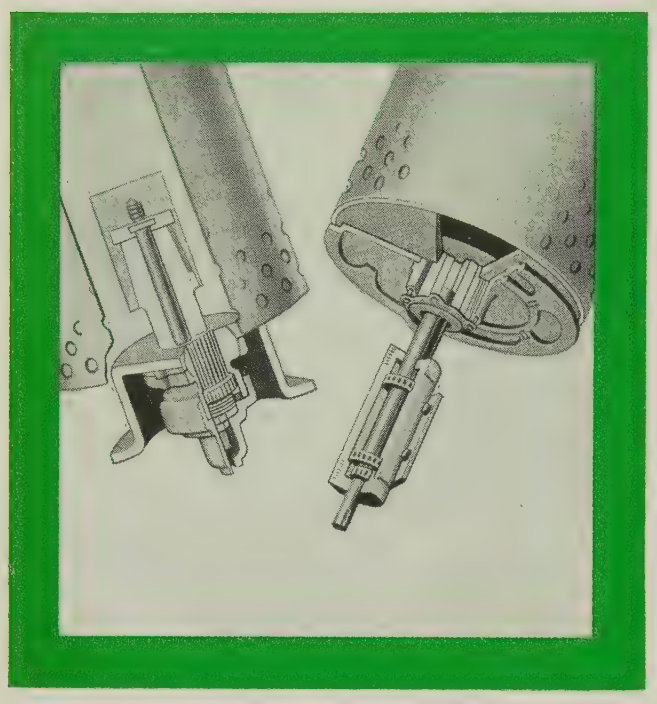

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pines (nine trees age 17, four trees age 50), the core wood was found to have the following characteristics:

1. Core wood specific gravity tends to vary inversely with height in tree to about 10 ft. from the base of the tree, then becomes relatively constant all the way to the 4-in. top. For practical purposes, core wood can be considered to have a uniform specific gravity within an individual tree. In marked contrast, the outer drops rapidly in specific gravity, with increasing height in the bole.
2. Core wood is considerably lower in specific gravity than mature wood of the same tree at any position up the tree. This difference becomes smaller toward top of the tree.
3. In young loblolly and slash pines there is a very close association between the specific gravity of core wood at breast height (4.5 ft.) and that of the entire zone of core wood ($r = 0.88$ for slash pine, $r = 0.77$) for loblolly pine). Similar close relationships exist between core wood specific gravity and the specific gravity of the total tree bole. It was found that, especially for specific gravity, the "predictive value" of core wood is high, either as an indicator of the values for the core wood of the whole tree, or for all the wood (core and outer) of the tree.
4. Cellulose yields showed the following trends: For slash pine WRC of core wood increased over 3% from breast height to tree top, while alpha-cellulose dropped very slightly from base to top of tree. Loblolly pine had a similar pattern, the WRC of the core wood increasing with height in the tree, while the alpha-cellulose remained nearly constant from base to top of the tree.

A discussion of the significance of pitch depositions and heartwood formation and their effects on specific gravity and cellulose yields is included. Considerations of the value and limitations of core wold are made in addition to discussions of the significance of this concept to forestry practices. .

B-4. Natural Variation in Populus Tremuloides Michx, J. P. Van Buijtenen, D. W. Einspahr, and P. N. Joranson, The Institute of Paper Chemistry, Appleton, Wis.

Populus tremuloides characteristically occurs in clones, originated as sprouts from a common root system. Natural variation between trees of this species may, therefore, be separated into variation within clones and variation between clones. The variation within a clone is environmentally caused. The variation between clones is caused by differences in environment as well as in genetic constitution

Diameter growth, volume growth, and specific gravity showed wide differences in one and the same clone as compared to between-clone differences, whereas fiber length showed less pronounced within-clone variation. Height growth, some properties related to tree form and some leaf characters (of value in recognizing a clone) showed a considerable degree of uniformity within clones.

These results indicate that selection for form promises to be effective as a method of aspen improvement, whereas selection for fiber length specific gravity and growth rate may be considerably less so.

Dissolving Pulps Session II

C-1. Degradation of Cellulose by Ultraviolet Light, J. H. Flynn, National Bureau of Standards, Washington. D. C.

Dried, purified, cotton cellulose sheets were irradiated in a vacuum at 40°C. with light of 2537 A wavelength. Hydrogen, carbon monoxide, and carbon dioxide were evolved, the degree of polymerization (D.P.) decreased, the CHO and COOH groups were produced. The rate of hydrogen evolution followed a parabolic rate law indicating inhibition by a product. The rate of evolution of carbon monoxide plus carbon dioxide increased slightly during irradiation. The initial quantum yield was 10^{-2} for hydrogen and 10^{-3} for carbon monoxide and carbon dioxide. A mechanism is proposed in which alcohol groups are photolyzed to carbonyl with the liberation of hydrogen.

C-2. A Bench-Scale Continuous Cellophane Casting Machine, E. E. Morse and H. de V. Partridge, Brown Co., Berlin, N. H.

This paper describes the constructon and operation of a bench-scale laboratory cellophane casting machine which was developed by Brown Co. and has been used for several years for the evaluation of wood cellulose for cellophane manufacture.

The machine casts a 5-in. wide gel film continuously at speeds up to 65 f.p.m. Purification, bleaching, and washing operations are carried out batchwise on 10 to 30 ft. lengths. The purified washed films are wound wet on heavy-walled glass tubes and air-dried.

The resulting films are used for determination of film yield, color, and clarity.

The effect of some variations in the viscose process on the casting operation and on film quality has also been studied.

Film yield, color, and casting bath sludge data are tabulated for a variety of North American dissolving pulps.

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The results of some process changes on casting bath sludge formation are also presented.

C-3. Outline for a Basic Study of the Differences between Cotton Linter and Wood Pulps, H. Kraessig and E. J. Howard, Industrial Cellulose Research Ltd., Hawkesbury, Ont., Canada.

Object

To uncover the differences between cotton linters and wood dissolving pulp and to aid in the development of a wood pulp grade equivalent to linters.

Basis

There is evidence that cotton linters are (A) chemically a more pure form of polyglucan than wood pulp and (B) and more uniform in their morphological fine structure due to less severe treatment applied in their preparation.

These two facts should be the basis of this research program.

A. Influence of Pulp Impurities

1. The noncellulosic impurities in pulps prepared from various wood species by standard cooking and bleaching procedures need to be properly identified. Special interest should be devoted to the nature of the hemicelluloses, resins, fats, and lignin as they exist in the various woods and the modifications which they undergo during the sequence of treatments (e.g., hydrolysis, oxidation, etc.) to convert wood commercially into finished pulp.

2. The behavior of these impurities as well as those of cellulose decomposition products in the finished pulps should be explored during the course of cellulose reactions (xanthation, acetylation, etc.). A careful study of the solubility of the derivatives of such impurities and cellulose decomposition products may reveal how they interfere with the use of wood pulps as starting material for cellulose derivatives.

3. Exploration of improved methods for eliminating impurities from wood pulps. Modification of conventional methods or entirely new pulping methods may lead to pulps with less impurities and better chemical and morphological structure than those at present in commercial use.

4. Influence of various types of impurities on the accessibility (hornification).

B. Influence of Morphology on Reactivity

1. Study the fine structural state in which cellulose is naturally laid down in wood compared with cotton.

2. Find which treatment during the conventional isolation of wood cellulose causes the partial destruction of the possibly better natural fine structure of the cellulose molecules.

3. What influence has this destruction of the fine structure on reactivity, tendency to hornification, etc.

4. Wood pulps contain often significant amounts of cellulose II. Study methods of activating cellulose II.

Forest Biology Session II

D-1. Estimation of Pulp Yield and Quality of Living Trees from Paired-Core Samples, R. M. Echols, Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Gulfport, Miss.

The Southern Institute of Forest Genetics at Gulfport, Miss., is using pairs of 10-mm. increment cores to determine the potential pulp yield and wood quality of southern pines. The cores are extracted from opposite sides of each selected tree at a height of 3 ft. above the ground. The increment borer holes are plugged, and steps are taken to protect the trees from insects and disease so that they may be used in future breeding work. A special cutting instrument has been developed to separate the cores into 51-mm. segments for more rapid specific gravity determinations. The application of weighting factors compensates for the increased volume of wood represented by segments successively farther from the pith. When the average specific gravity of the stem of the tree, the age, and the average diameter inside the bark at the 3-ft. level are known, a numerical rating, or wood quality index value, is determined from a nomogram. This index is the number of equivalent pounds of pulp formed per year in the lowest 5-ft. bolt of wood in the tree. Procedures are given for rapid determination of fiber lengths, and the method lends itself well to the handling of large numbers of wood samples.

D-2. A Test Method for Single Fibers in Tension, B. A. Jayne, School of Forestry, Yale University, New Haven, Conn.

D-3. A Method for Rapid Routine Determination of Cellulose from Wood Cores, A. P. Yundt and K. E. Bradway, Union Bag-Camp Paper Corp., Franklin, Va.

Alkaline Pulping Session

E-1. Pressurized High Consistency Screening in the Pulp Mill, R. Cross, Black-Clawson Co., Hamilton, Ohio.

Pressurized screening has come a long way since its inception over 18 years ago when the original pilot model was built out of standard steel pipe at Middletown, Ohio.

Today, with many of these machines in operation on stock preparation and paper machine applicatons, they are universally accepted on the basis of an outstanding performance record.

Recently, pressurized screening has proved very successful applied in the pulp mill. Several of the benefits which have been experienced are:

1. By operating under pressure, the screens can be located ahead of the washers. As the stock usually requires less redilution than is presently used, deckering requirements and other related equipment can be reduced or oftentimes eliminated.
2. Screens perform efficiently on high consistency stocks due to the efficient action between the rotating element and the screen cylinder, making possible high throughput rate with low horsepower requirements
3. Certain screens do not require internal shower water.
4. They provide a neat, compact installation.

Excellent results have been obtained with pressurized screens operating ahead of washers on softwood kraft pulp in a Southern linerboard mill. By performing good screening at this point, subsequent deckering requirements are reduced, as the need for further screening of the washed stock in the pulp mill is eliminated.

Further experience has been obtained in a similar application at another linerboard mill with a larger pressurized screen. Accepted stock tonnage ranged to well in excess of 300 tons per day.

The principle has been proved on neutral sulphite hardwood pulp in a Northern mill, where pressurized screening is again effective prior to washing. The pulp is later bleached for use in printing and publication papers.

Extended trials have been made on groundwood pulps in a Northern mill. Throughout quality and ease of operation are very favorable.

E-2. Elimination of Bad Odors in a Kraft Pulp Mill, K. G. Trobeck, Aktiebolaget B-T Metoder, Stockholm, Sweden; W. Lenz, and A. Tirado A., Fábricas de Papel Loreto y Peña Pobre, S. A., Villa Obregón, D. F. México.

Experiences in the kraft pulp mill of Loreto and Peña Pobre indicate that only three sources of bad odor will remain, if the black liquor is properly oxidized. These three sources are: gases produced by the digesters, condensates also produced by the digesters, and gases delivered by the stack of the recovery boiler. An installation for the elimination of odors from gases and condensates from digesters, and one similar installation for handling gases going to the stack of the recovery boiler, have been successfully operated in Loreto and Peña Pobre for about one year. Use is made of the reaction between chlorine and gaseous sulphur compounds; however, a preliminary treatment of the sulphur compounds with air in presence of water has been demonstrated to bring about additional benefits as well as a definite saving of chlorine. Results of tests made to improve and clarify the different stages of the odor elimination system—including black liquor oxidation—are discussed in the paper.

E-3. A Study of the Dependency of Pulp Yields Upon Method of Determination, M. J. Showalter and D. A. Feigley, Jr., Armstrong Cork Co., Lancaster, Pa.

Pulp yields depend upon the method of determination. Yields might be defined in two ways:

1. The ratio of dry wood substance coming out of the pulping process to that in the logs.
2. The ratio of wood substance obtained in the finished paper to that in the logs.

It would seem obvious that the latter is the only logical and significant comparison from the papermaker's standpoint. Unfortunately, there is no standard method of yield determination. A comparison of yields as determined by the two methods is made for:

1. Straight steam cooks.
2. Two-hour caustic soda steeps at room temperature and atmospheric pressure.
3. Twenty-minute caustic soda steeps at room temperature and elevated pressure.

For identical treatment of a wood species, the "consistency" method of yield determination is lower than the "dry weight" method. It is proposed that some effort be made to standardize the method of determining yield, particularly as applied to semi-chemical pulping.

E-4. A Critical Study of Short-Period Caustic Pulping of Wheat Straw, A. J. Ernst, T. F. Clark, and H. J. Dutton, Northern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture; and M. D. Finker, Biometrical Services, USDA Plant Industry Station, Beltville, Md. (present address: New Mexico College of Agriculture and Mechanic Arts, State College, N. M.).

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A statistically designed and replicated experiment to study 15 min. pulping of wheat straw was carried out at caustic concentrations of 4 to 10% (basis straw) and temperatures of 100° to 180°C. Data were acquired on tests of customary handsheets as well as machine-made 9-point corrugating produced on a 10-in. laboratory fourdrinier machine. The complex pulping data are presented in tabular form, in topographical presentations, and in statistical evaluations.

Cylinder Board Session I

F-1. What Is Good Formation?, G. R. Sears, The Institute of Paper Chemistry, Appleton, Wis.

Formation refers to the uniformity of distribution of each furnish constituent in a web of paper or paperboard, or in each ply in the case of a multi-ply sheet. The more uniform this distribution, the better is the formation. Uniform distribution requires more than constant density or concentration of the constituent throughout the web—i.e., across the web, along the web, and through (top to bottom) the web. The distribution is uniform when the concentration and "basis weight" of the constituent are constant. Thus, in its most general sense good formation requires the absence of local nonuniformities in the web and also the absence of two-sidedness and of variability from front to back of the web and from end to end of a roll.

F-2. How Furnish Affects Formation, L. V. Hoffman, Container Corporation of America, Wabash. Ind.

The formation of liner stock actually run on a cylinder machine was inspected in this study. The following furnishes were used as a basis for formation comparison:

1. Canadian unbleached kraft pulp
2. Western semibleached kraft pulp
3. Western bleached kraft pulp
4. Southern semibleached kraft pulp
5. Southern bleached kraft pulp
6. Western bleached sulphite pulp
7. Southern bleached hardwood pulp
8. Hard white envelope cuttings
9. Tabulating cards

A method for comparing formation of paperboard is described and discussed.

From a study of these formation samples, it becomes apparent that the southern softwood kraft pulps tend to form better than the longer western kraft pulps, and that the hardwood pulps will give still better formation.

Certain wastepaper furnishes will give very good formation, which is due to the extra papermaking process to which they are subjected.

This study points up the need for a good method of accurately demonstrating and measuring the quality of formation in paperboard.

F-3. Stock Formation for Good Formation, G. B. Nicholson, Federal Paperboard Co., Inc., New Haven, Conn.

F-4. Machine Design and Cylinder Machine Formation, W. S. Milne, The Black-Clawson Co., Portland, Ore.

The purpose of this paper is to explore some of the areas in which machine and equipment design affect the formation and, thus, the finished sheet of multicylinder board. It presents a definition of formation with qualifying remarks to compensate for the varied end uses of the products.

In this paper a check list is supplied, along with comments regarding the influence of certain design elements on the papermaking operation. Areas covered include vat system components, vats and cylinder molds, and primary water removal equipment on the making felt.

F-5. Effects of Cylinder Machine Operation on Formation, H. E. Hadley, Diamond Gardner Corp., Gardner Div., Middletown, Ohio.

This paper attempts to illustrate some of the factors in the actual manufacturing operations that influence the formation of the sheet. This includes discussions of the use of mixing boxes, the approach to the vats, the removal of white water from the cylinders, and also the mechanical adjustments which are available to the operator. It will also attempt to discuss the handling of paper machine clothing and its effects on formation; also roll nip pressures and their effect.

Fluid Mechanics Session

G-1. Secondary Motions in Flow Between Concentric Rotating Cylinders, D. W. Appel, University of Kansas, Lawrence, Kan.

The results of a study of fully developed secondary motions in the flow between concentric cylinders, with the inner one rotating, are reported herein. These motions, called Taylor vortices, have been shown to have important effects on the flow through fourdrinier paper machines.

Existence of both laminar and turbulent regimes of flow in Taylor vortices was established. The strength of the vortices was measured and found to increase linearly with increase of the rotational speed of the inner cylinder up to the point of transition to turbulent motion. Thereafter, the strength of the vortices was found to reach a maximum and decrease with further increase of the speed of the cylinder. The effects of adding an axial discharge between the cylinders were also studied. Under certain conditions, boundary layers formed on the cylinder walls due to the through-flow, thereby confining the Taylor vortices to the central part of the annulus. However, with higher cylinder speeds and correspondingly stronger vortices, these boundary layers were obliterated.

From this study a better understanding of this type of secondary flow has been obtained. The results are presented dimensionlessly to facilitate their application to problems encountered in the flow-through paper machines.

G-2. Instability of Flow on the Fourdrinier Wire—Report on TAPPI Project No. 140, C. S. Yih and A. C. Spengos, University of Michigan, East Lansing, Mich.

An analysis for the growth of disturbances as they pass over the table roll has been performed. Measurements made on the model for the rate of growth at different speeds verify at least the trend predicted by the analysis.

Measurements for the ratio of the maximum amplitude after the table roll to the amplitude at the beginning of the table roll have been made for two "step-downs" (simulating two conditions of wire wrapping) at different Froude numbers. The amplitude ratio increases with the distance of step-down, i.e., with the slackness of the wire, and with the Froude number. The results are quite consistent.

A thorough analysis for the occurrence of liquid rings on the surface of the table rolls has been performed, with the effect of viscosity and surface tension included. For different Reynolds numbers and Weber numbers the critical wave length (or spacing) and the corresponding (maximum) growth rate of the rings can be found.

G-3. Internal Pressure Distributions in Compressible Mats Under Fluid Stress, W. L. Ingmanson, B. D. Andrews, and R. W. Johnson, The Institute of Paper Chemistry, Appleton, Wis.

As the initial work in a study of the nature of fluid flow through compressible fibrous mats the internal pressure drops were measured within fiber beds under fluid stress. Because of the cumulative effect of frictional drag forces acting on individual fibers, it has been hypothesized that compressible porous beds under the influence of an over-all fluid pressure drop will have a porosity distribution from a maximum at the upstream mat face to a minimum at the downstream septum. This porosity distribution should determine the internal pressure drop distribution. Data are presented for mats of synthetic fibers and wood pulp fibers in which experimental values of internal pressure drops are compared with calculated values based on static measurements of mat compressibility. Good agreement was obtained by using empirical modification of the Kozeny-Carman equation to allow for large variations in the so-called Kozeny constant in high porosity fiber beds.

G-4. Secondary Flow Phenomena in Nonlinear Fluids, J. L. Ericksen, Johns Hopkins University, Baltimore, Md.

In a variety of situations where classical fluid dynamics predicts a simple shearing type of motion, many nonlinear theories predict a qualitatively different type of motion. This occurs for example in slow flows through circular pipes, between concentric spheres or coaxial cones in relative rotation and in wedge flows. The motion can generally be viewed as obtained by superimposing a secondary flow on a simple shearing type of flow. A qualitative description of these flows is given. We also give an elementary description of theories which predict secondary flows, including simple criteria for ascertaining whether a given theory will predict a given type of secondary flow. Experimental evidence concerning secondary flows is rather meagre. Pertinent observations are described.

G-5. The Friction of Paper Stock in Pipes—Summary of TAPPI Research at the University of Maine, "A New Method for Calculating the Pipe Friction Loss of Paper Stock," a sound movie presented by the TAPPI Hydraulics Committee, with comments by K. J. Mackenzie, Eastman Kodak Co., Rochester, N. Y., chairman.

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Adhesives Testing Session

H-1. Predicting the Glueability of Milk Carton Stock Board, H. J. Ladue, American Paper Bottle Co., Walled Lake, Mich.

Aim: To develop a laboratory test or series of tests to predict the glueability of milk carton stock board.

Much of our investigation thus far has been concerned with measuring the strength of bond between paper and a standard Dennison wax stick using the Instron tensile tester. Areas of investigation have included: (1) selection of wax stick (1–32), (2) effect of wax temperature at time of bond, (3) effect of pressure applied so stick in preparing sample, (4) effect of area of bond, and (5) reproducibility of results.

Other methods of testing being studied are:

1. Standard Dennison wax pick test
2. Rate of set test
3. Cobb size test
4. Absorbency test
5. Penescope test

H-2. Evaluating Industrial Adhesives, H. G. Maeder, Dixie Cup Div., American Can Co., Easton, Pa.

Recent critical laboratory examination of the rheological behavior of certain industrial adhesives has led a close correlation with machine performance. Measurements made under conditions simulating actual use take nearly all of the uncertainty out of conventional adhesive testing procedures. Although much still remains to be learned, a good start has been made toward eliminating the "art" of adhesive testing. This paper describes a simple viscometer that has been found useful in predicting adhesive behavior in a paper converting operation.

H-3. Adhesion, H. F. Mark, Polytechnic Institute of Brooklyn, N. Y.

Good adhesion requires the combination of two factors:

1. Rapid establishment of a large contact area between adhesive and substrate and
2. Formation of strong bonds between these two components of the cemented systems.

If one wants to explain the behavior of adhesives presently in use and also if one is looking out for the synthesis of still better materials one tries to accomplish the combination of the two above conditions by the following molecular characteristics of the adhesive:

1. The chains of the polymer which is used must have a high degree of internal mobility so that they can diffuse rapidly at the surface of the substrate and establish a large contact area in a short time at a given temperature and
2. These chains must carry a sufficient number of polar, or even better, hydrogen bonding groups which are capable of establishing strong intermolecular bonds.

A number of examples for successful compromises of these two factors will be given.

Statistics Session I

I-1. Acceptance Control Charts, C. H. Chandler, Eastman Kodak Co., Rochester, N. Y.

The application of acceptance control charts to Eastman Kodak's color processing operations is described. Acceptance control charts differ from the conventional Shewhart control charts in the following ways.

1. They define a range of "acceptable process levels" which in effect substitutes a "standard zone" for a standard line.
2. They define the "rejectable process levels" which result in unacceptable product.
3. They include a method for determining the sampling required to guarantee not rejecting an "acceptable process" and not accepting a "rejectable process" more frequently than the chosen alpha and beta risks, respectively.

In many production operations there are systematic shifts in the average level due to batch operations, shutdowns, or other causes. These level shifts can often be tolerated with no detectable effect on product quality. When using acceptance control charts, the zone of acceptable process levels would include such systematic level shifts, and thereby costly production changes aimed at reducing variability in levels could be avoided. Control limits beyond the acceptable process levels are calculated from inherent process variability using the sampling required to satisfy the alpha and beta risks.

In changing from the Shewhart type control charts to acceptable control charts for Kodak's color film processing operations the following benefits have resulted:

1. There is a better understanding of the relationship between control charts and customer product acceptance.
2. More reasonable control requirements have been placed on the individual processing operations.
3. There is more confidence in the interpretation of control results

I-2. The Evaluation of Testing Methods, J. Mandel, National Bureau of Standards, Washington, D. C.

The several sources of variability in test methods are examined and a new general scheme to account for them is proposed. The assumption is made that errors due to systematic sources are essentially linear functions of the magnitude of the measurements. This model leads to a simple design for the study of test methods on an interlaboratory scale. It requires a new method of analysis, geared to the practical objectives of the round robin. The general problem of the use of standard samples is discussed in the light of the proposed method. The presentation includes examples of both physical and chemical test methods used in the paper industry.

Corrugated Containers Session I

J-1. Quality Control for Today's Requirements, L. S. Johnson and B. Mendlin, Cornell Paperboard Products Co., Milwaukee, Wis.

Modern methods of packaging, transporting, and storing materials require a higher and more uniform performance level from corrugated containers. To obtain this performance level, greater emphasis must be placed on quality control. This control is an over-all function starting and ending with the customer, including solicitation of the order, manufacturing, inspection and testing, and shipment of the goods. Solicitation of the order must include obtaining complete specifications that represent performance requirements. These requirements must be suitably translated into manufacturing orders so materials and manufacturing processes can be properly selected and correlated. With performance requirements properly established suitable inspection and testing points are selected. No single routine of inspection and testing is advisable from both an economic and control viewpoint because of the varying nature of performance requirements.

A number of quality control functions are presented to illustrate the general plan (and philosophy) used by Cornell Paperboard Products Co.

J-2. Quality Control Inspection from the Customer's Viewpoint, R. T. Holt, Scott Paper Co., Chester, Pa.

Scott Paper Co. believes primarily in establishing practical and sound specifications for corrugated cases which will allow the company to deliver to its customers high quality products in the best possible condition. Emphasis is placed on establishing compression standards to comply with Package 215 of the Uniform Freight Classification Manual.

Of similar importance is the supplier sampling procedure coupled with the retest sampling and testing procedure should this be necessary.

Quality acceptance of the material supplied is reached by means of a thorough process of sample preparation and testing. Top to bottom compression and selective eye mark location are two factors of major importance.

As an aid to the purchasing department a quarterly report is issued which compares the quality performance of case suppliers. The report also emphasizes those areas in which suppliers are weak.

J-3. Testing Machines Available for Quality Control, W. Bachelder, Testing Machines, Inc., Mineola, L. I., N. Y.

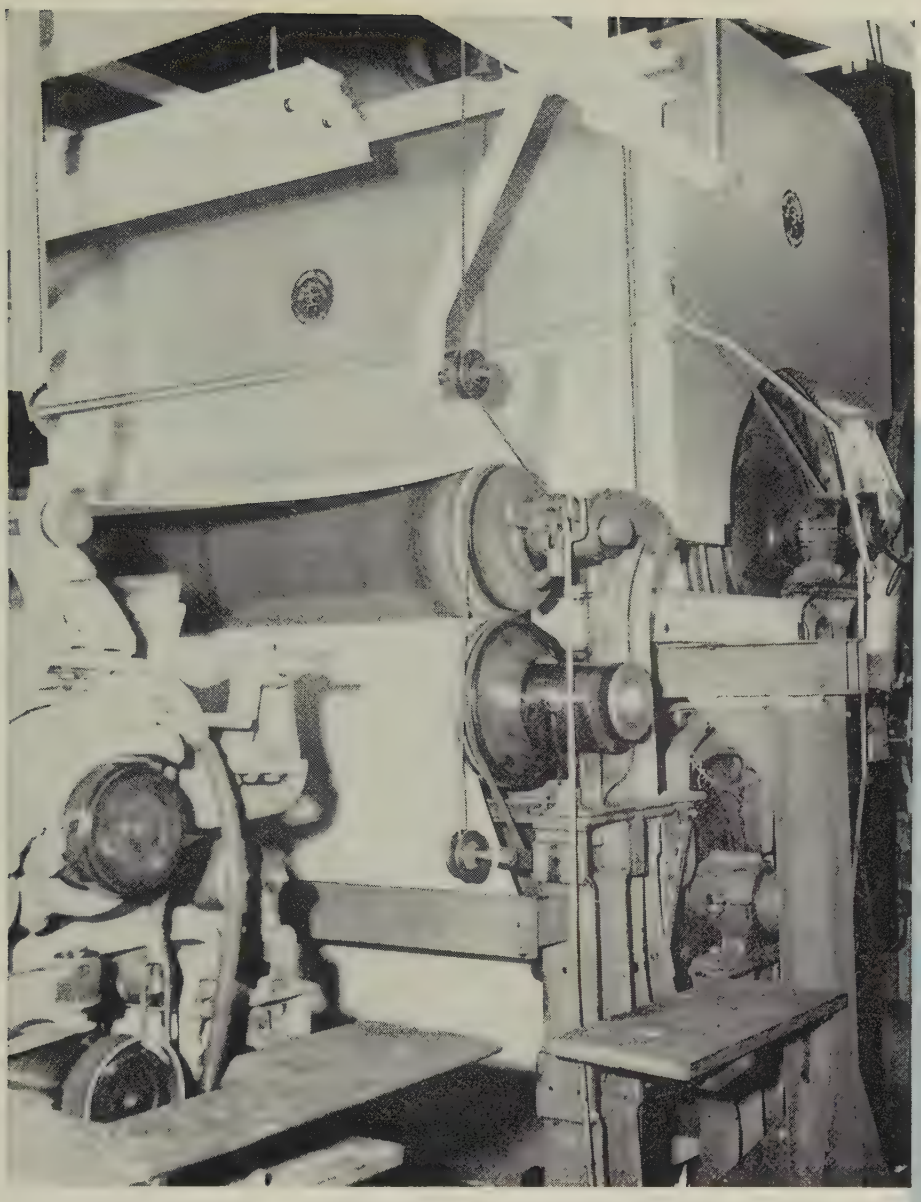
Sound, precise testing machines are necessary for quality control measurements in these days of scientific activities. However, it is required that these be used with skill. Preparation of specimens must be done carefully or the test results will be meaningless.

There are many hundreds of testing devices available from the United States and foreign countries. Here are descriptions of many of them in at least a dozen different categories, all suitable for quality check testing. Purposes and general characteristics are stated.

For reliable results in any of these tests, the testing machine used, the method employed, and the intent of the test must be given careful consideration.

J-4. Some Aspects of Sampling for Specifications, G. G. Maltenfort, Container Corp. of America, Chicago, Ill.

Solutions to two practical sampling problems are discussed: (1) A method for random sampling rolls of paper such a medium and liner is given, and (2) a method is suggested for combining attribute (go—no go) and variables (measured characteristics) into a single quality control system. The problem of reproducibility, how it is affected by the variability of the data, correlation of scatter to test level, and sample size is discussed, particularly in its implications on setting up specifications. The paper concludes with a short discussion of the basic factors influencing



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acceptance sampling for specifications, and the necessity to reconcile probability sampling concepts with standard TAPPI and ASTM test procedures.

Fourdrinier Session

K-1. Experiences in the Use of All-Synthetic Drier Felts, E. Race, Scapa Dryers Ltd., Blackburn, England.

K-2. Location and Operation of Automatic Wire and Felt Guides, H. W. Brown, Gilbert & Nash Co., Appleton, Wis.

A practical discussion dealing primarily with the problems of the papermaker in getting the maximum life from the machine clothing by preventing unnecessary damage as a result of ineffectual automatic guide location.

The discussion includes a brief history of guiding, guide operation, types of guides, wire guide locations, felt guide locations, preventive maintenance, and a general summation of correct guide installation.

History

Development of the automatic guide during the past 60 years. Early guides were manually operated or semiautomatic requiring constant attention from the machine tender. Excessive pressure of the web against the sensing device to actuate the guide usually resulted in undue wear or damage to the web edge.

Guide Operation

How an automatic guide controls the web. Angle of "wrap" or area of contact of web over roll and its effect.

Modern Automatic Guides

Mechanical, air, hydraulic—a description of how they work.

Wire Guide Locations

Locations for the wire guides on older paper machines was on the top run of the wire between the suction boxes and the couch roll. Disadvantages—advantages. Best locations for a guide on the wire return. Distances between guide roll and carrying rolls.

Felt Guide Locations

Generally, felt guides are located in the same manner as wire guides. Ordinarily, felts respond more readily than wires to movement of the guide roll because the felt is more pliable and is easily steered. More liberties may be taken with guide location.

Preventive Maintenance

Because the automatic guide is vital in preventing not only wire or felt damage, but costly down time on the machine a definite program of preventive maintenance should be established. For mechanical guides this program should include proper lubrication, inspection, and replacement of worn parts, periodic cleaning, and a good stock of spare parts. Air guides should be thoroughly checked regularly, air filters and lubricators kept clean, cylinders rebuilt or diaphragms replaced at predetermined intervals to eliminate the possibility of failure.

Summary

Proper guide operation is directly relative to the friction necessary on the guide roll to effectively overcome the tendency of the wire or felt to run off the machine.

K-3. Suction Roll Theories, C. H. Swartz, Beloit Iron Works, Beloit, Wis.

Cylinder Board Session II

L-1. Cylinder Board Formation, Measurable or Predictable?, T. E. Brookover, Downington Paper Co., Downington, Pa.

Our own and industry representatives' opinions of formation versus the reality of production formation led to interest in a method of measuring formation, preferably in production.

References to formation were reviewed in *Tappi*. General statements on formation quality have been the rule, and standards on which to judge formation have not been uniform.

Methods of sampling individual plies from board production are tedious, time consuming, and do not allow truly representative sampling, precluding the use of existing methods of formation measurement for control purposes.

The requirements for formation evaluation satisfactory as a production control tool would be stringent, and localized test spots appear unsatisfactory for representative sampling of today's conventional operations.

Some discrepancy may exist between our conception of necessary formation quality and the actual formation quality required and acceptable by the converting industry.

Considering industry's failure to develop satisfactory quantitative formation evaluation and the difficulty of "scanning" production formation, recent industry developments indicate that "predictable acceptable" formation may be a more realistic and attainable goal.

Acid Pulping Session

M-1. Developments in Swedish Sulphite Pulping, L. G. Stockman, Swedish Central Research Laboratory, Stockholm, Sweden.

M-2. Correlation of Vapor-Liquid Equilibria in the Systems SO_2–H_2O–NH_3 and SO_2–H_2O–Na_2, Using an IBM 650 Computing Machine, H. Gaskill, R. Fleming, V. F. Felicetta, and J. L. McCarthy, University of Washington, Seattle, Wash.

M-3. Operation of the 1957 Experimental Sodium-Base Recovery Plant at Consolidated Water Power and Paper Co., S. R. Parsons, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis., and R. Q. Boyer, Western Precipitation Corp., Los Angeles, Calif.

This plant, designed for expansion, was completed in June, 1958, and has been operated on acid sulphite and NSSC spent liquor singly and in mixtures to obtain recovery data.

The mill scale tests on liquor treatment evaporation and burning conducted in 1953 at Nekoosa, have been reported. This plant includes similar spent liquor treatment systems and the identical evaporators used before to give a 65% feed at the furnace. The unit operations necessary to complete the cyclic process are reported in this paper.

The recovery furnace is equipped with shot cleaned air heaters giving 325°F. outlet gas temperature without difficulty. The flue gas sulphur dioxide is recovered in a 0.5 in. draft loss tower proposed by H. F. Johnstone. The green liquor is treated in an evaporator-crystallizer capable of producing sodium sulphide mother liquor to 90% sulphidity. The sodium carbonate is separated from the mother liquor on a rotary filter with less than 1.5% sodium sulphide retention.

The major start-problems were losses, crystal size control, salt setting, salt filtration, and dirty tower solution effluent. The major loss, furnace entrainment, was shown to vary as the square of the liquor feed rate. Mechanical collectors were installed to control this. Precoat leaf filters are used to clarify the tower effluent. Some equipment revisions but mainly consistency of operation was used to control the other problems.

Furnace experience shows that the sulphur dioxide release is more favorable to the process than previously assumed. Excess sodium carbonate in the liquor does not capture additional sulphur in the smelt. The previously reported 50% smelt sulphidity rule holds only when all losses are made up with sodium sulphate. The furnacing factors inherently control the material balance to give a cyclic recovery process. Sustained operation, recycling the sodium sulphide produced in the process without sulphide buildup confirms the validity of the process theories.

The combination of low temperature air heaters and forced circulation concentration eliminates the usual direct contact evaporation. This combination appears to be just as valid for kraft recovery. The sulphidity rules can also be a value in the kraft industry.

Statistics Session II

N-1. Evolutionary Operation in Chemical Processes, J. C. Whitwell, Princeton University, Princeton, N. J.

The first requirement of a chemical plant is that it shall maintain production. However it is axiomatic that the plant operation is not optimum without some experimentation. The effectiveness of individual experiments is limited by the necessary restriction of maintenance of production and the consequent requirement of very small changes in variables. Thus a situation is automatically established whereby small effects are studied in the presence of relatively large amounts of "noise," the latter generated by uncontrollable process variation.

Evolutionary operation is a system of integrated experiments involving only small variable changes. It is designed first to sharpen the distinction between changes produced by variables and those resulting from noise, and second to allow a number of variables to be studied concurrently. At no time does it interfere with normal operation. It is, then, a method whereby the plant is run to produce, coincidentally, product and information.

The calculations of the results are not extensive or complicated. The decisions regarding desirable process changes are made by the plant personnel, not the statistician.

The elements of this system, which is already highly successful both in this country and abroad, are described. Illustrative data are presented.

N-2. Example: An Application of Fractional Factorial Designs to a Study of Papermaking Variables, R. W. Roberts, Marathon Div., American Can Co., Menasha, Wis.

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Corrugated Containers Session II

O-1. A New Revolutionary Concept in the Art of Corrugating Paperboard—The Old and the New Compared, H. W. Wilson, Royal Container Co., San Francisco, Calif.

The author relates how in collaboration with the S & S Corrugated Paper Machinery Co., Inc., a new concept in corrugating paperboard was developed that solves many of the problems presently confronting boxmakers.

O-2. The New Greenwood Quick-Setting Multicolor Printer-Slotter, W. W. Wagner, Jr., Eastern Box Co., Baltimore, Md.

A history of the development of the new machine with a background of the problems which this unit is designed to answer is presented.

A full description of the new machine complete with slides covering the various phases of its operation from the feed end through to final delivery of the box blanks with a brief detailing of the various mechanical principles employed follows. This includes a step by step outline of how the quick setup feature will be accomplished.

The conclusion of the presentation concerns itself with facts and figures relating to the actual operation of the first of these presses in the plant of the Eastern Box Co. at Baltimore, Md.

O-3. Operating Experiences on the S & S Type C Die Cut Press, D. M. Davis, The Hercules Box Co., Div. of Federal Paper Board Co., Inc., Columbus, Ohio.

The paper presents a brief description of approximately 9 months' experience on this press. Two types of setups are involved, standard with spot sheets and with no spot sheet involved. The latter will comprise about 30% of the jobs run. Production speeds are discussed and the most critical elements of setup described are: paper register stop, position, and timing. The most persistant operating difficulty is the tendency of lightweight and bleached paper to strip themselves in the delivery section. Advantages of this machine over more conventional die cutters have been high production, much larger cutting rule life, better register, and less scrap.

O-4. Printing and Die-Cutting Are a Reality on the Swift Gluer-Folder, E. S. Schneider, United Container Co., Philadelphia, Pa.

Gluer-folders are no longer new to the corrugated box industry, but what is new about the latest model now on the market is that it will also print and/or die-cut. Known as the Glu-Lok, this latest design gluer-folder has some other features which may be of interest to the cost-minded corrugated boxmaker.

This paper, based mainly on the experience at United Container Co. since mid-September with a size 31 by 78 in. pilot model Glu-Lok, explains briefly how the box or blanking section, and the folding section differ from other makes. The printing feature of the machine is covered in greater detail because the facilities employed and procedure followed are so unique in printing RSC boxes up to four panels in one color. Also disclosed is how die-cutting is accomplished, either alone or at the same time blanks are printed, providing both operations are not in the same panels'

O-5. Summary of Operating Experiences on the 42 by 62 In. Bobst Die Cut Press, Contributed by many users.

This paper presents a composite summary of the experiences of various box plant users of the 42 by 62 in. Bobst die cut press.

Makeready time and production speeds are described in each of three different models, (a) automatic feed, roll off delivery, and no stripping stations; (b) automatic feed, in-line delivery in one automatic stripping station; (c) automatic feed, in-line delivery in two automatic stripping stations.

Appropriate slides accompany the reading of the paper.

Graphic Arts Session

P-1. Reproducibility Studies of Pick Measurements—Progress Report from TAPPI Research Project 130, W. D. Schaeffer, J. M. Fetsko, and A. C. Zettlemoyer, Lehigh University, Bethlehem, Pa.

Existing pick measuring techniques are being investigated with the objective of recommending one as a TAPPI standard method for evaluating the pick resistance of paper. Two phases of the program are described: (1) a study of the reproducibility of pick testers available at Lehigh and (2) results from the initial round robin test.

Five pick testers under evaluation at Lehigh were the Dennison Wax Test, LTF Pick Tester, IGT Printability Tester, Hercules-Brookfield Print Tester, and the Waldron Pick Tester. A study of their reproducibility was made by performing tests on four different stocks on 10 different days. The instruments were generally operated according to the instructions recommended by the manufacturers. Analysis of the results indicated that day-to-day variation is a problem particularly with the instruments which measure picking speed. Discrepancies in ranking the stocks were also noted.

A round robin test was conducted to determine the reproducibility of the five aforementioned pick testers available in different laboratories and to evaluate the performance of six additional methods not available at Lehigh. Sixteen cooperating laboratories plus Lehigh submitted 30 sets of pick measurements. Each set consisted of four pick tests on each of five days on six samples of 70 lb. offset machine coated paper. Many of the results confirmed the findings made previously in the Lehigh laboratories.

P-2. A Study of the Surface Characteristics of Paper and Paperboard as They Relate to Printing Smoothness—Progress Report from TAPPI Research Project 139, G. R. Sears and W. A. Wink, The Institute of Paper Chemistry, Appleton, Wis.

This report presents data obtained from the TAPPI project entitled, "An investigation of smoothness and compressibility of paper and paperboard as related to printability." Four paper samples and four paperboard samples of greatly differing printing characteristics were examined. The applicability of the Wink and Van den Akker nip-spreading technique* for measuring a roughness index and, thereby, smoothness was studied and it was found that the range of roughness indices of the samples was great. Thus far the nip loads ("pressures") used in the nip-spreading tests have been much less than the nip loads in commercial letterpress printing. The correlation of this smoothness ranking with printability as judged by press tests in three laboratories was not good. Of course, it is not to be expected that smoothness alone would determine printability. The paper and board samples were also examined with respect to Chapman printing smoothness, gloss, surface contour, and formation. The interrelation of these several properties and test results are given. The correlations of rankings of the paper and board samples by roughness indices and by other test data are expected to improve as the nip loads in the nip-spreading test are increased.

P-3. Photographic Examination of Paper and Paperboard Surfaces to Predict Halftone Printing Quality, R. O. Ragan, Chicago Carton Co., Chicago, Ill.

The fiber topography of a paper surface to be printed with halftones, particularly by the gravure method, has a direct bearing upon the continuity and fidelity to the halftone reproduction. As attempts to define surface smoothness in terms of instruments have not been entirely successful, a photographic technique and camera has been devised for the purpose of making quick visual comparisons of printing surfaces.

It was found that the conventional method for making photomacrographs through a microscope equipped with bellows and plate attachment was not entirely suitable as a quality control instrument.

A portable, self-contained camera which can be used without cutting out samples, and one in which the illumination angle and intensity is constant, is described. The camera has provisions for readily locating the desired area from a magnified scanning of a one inch area; the focusing s semifixed so that the photographs are at the same magnification. The apparatus is used for visual inspection as well as for photographs.

Paper surfaces containing no mineral filler, or clay coatings, can be made to photograph more distinctly by wiping with an alcohol suspension of titanium dioxide.

Photomacrographs showing the nature and suitability of various paper and paperboard surfaces for halftone printing are presented. The need for complete surface uniformity is demonstrated. The use of photomacrographs as a means for defining to the paper mill the desired printing surface improvements is illustrated and discussed.

P-4. Some of the Factors Affecting the Printing Quality of Newsprint, R. W. Prince, ANPA Research Institute, Inc., Easton, Pa.

The ANPA Research Institute has studied some of the physical properties of newsprint that are associated with printability. Some 600 newsprint samples from 54 of the 56 North American newsprint mills were obtained from 54 newspapers over a 12-month period. A sampling procedure was developed which, it is believed, assures that test samples are received equal to, or closely approximating, the condition of the newsprint as used by the publisher. Fifteen physical properties were tested, utilizing equipment and techniques available to the industry. The data so obtained were examined statistically for probable relationship to printability. The printability test used for this purpose has

* Wink, W. A., and Van den Akker, J. A., "A new apparatus and procedure for determining the surface receptivity and roughness of paper as these relate to liquid film, applications," *Tappi* 40, No. 7: 528–36 (July, 1957).

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been previously described in the literature† and involves the use of a proof press under controlled ink and impression settings.

The findings were subjected to a multiple regression analysis in the belief that good printability results from a combination of several paper properties. From this analysis it was concluded that approximately 50.0% of the differences in printability are accounted for by differences in smoothness, hardness, and brightness. The remaining 50.0% are attributed to factors other than smoothness, hardness, and brightness.

Mathematical analysis indicates that, of the total variance in printability on the wire side, 31.5% is due to the effects of smoothness alone, 10.0% to the hardness alone, 2.5% to brightness alone, and 14.0% to a combination of smoothness, hardness, and brightness varying together.

Scatter diagrams have been prepared, plotting each of the measured physical characteristics against measured printability. Visual examination of these diagrams indicates that porosity and opacity together may account for another 10.0% of the printability variances, leaving approximately 40.0% of the printability variances to be accounted for. Basis weight, moisture, caliper and tear were found to be independent of printability.

Chemical Methods Session I

Q-1. New Approaches to Analysis and Testing of Pulp and Paper through Instrumental Techniques, S. Z. Lewin, New York University, New York, N. Y.

Although instrumental techniques of testing and analysis already play an important role in the procedures in use in the pulp and paper industry, the rapid development of this field in recent years has created instruments and techniques that are not yet being exploited. These new developments are surveyed, and the unique advantages each one offers for the solution of specific problems, or the simplification of current procedures, in pulp and paper analysis are discussed. The fundamental nature of an instrumental technique, as contrasted to a classical, "noninstrumental" method, is outlined, and the essential steps involved in developing a new method based on instrumentation are described.

Q-2. Dry Ashing of Pulp and the Factors Which Influence It, L. H. Phifer and J. B. Maginnis, American Viscose Corp., Marcus Hook, Pa.

A comprehensive study of the effect of the variables associated with dry ashing was made. The loss of large amounts of the metal ions including sodium and calcium through volatilization is demonstrated. This has led to the conclusion that dry ash values are of little value when comparing pulps and the method is in general unsatisfactory for sample preparation for inorganic constituents.

Q-3. Determination of Starch in Paper, J. L. Harvey, B. W. Forshee, and D. Fletcher, National Bureau of Standards, Washington, D. C.

The TAPPI, the enzymatic, and the spectrophotometric methods for the determination of starch in paper have been compared using six papers and four starches. Although none of the methods are completely satisfactory, the spectrophotometric method is more accurate and more precise than the other two methods.

Q-4. Direct Colorimetric Estimation of Xylose in Wood Pulp, K. A. Kuiken and A. F. Johnson, The Buckeye Cellulose Corp., Memphis, Tenn.

Color is developed by treating pulp with sulphuric acid and anthrone. Conditions are selected to give rapid development of the xylose color. High quality cotton linters pulp is added to the blank and reference standards, which are developed simultaneously, to compensate for a glucose color background. Mannose does not interfere. Optical density at 625 mmu versus xylose level follows Beer's law. Standard deviation of the method is 0.13%. Comparative data by other methods are presented.

Chemical Engineering Session

Q-1. Systems Engineering and Operations Research in the Pulp and Paper Industry, E. F. Thode, The Institute of Paper Chemistry, Appleton, Wis.

Systems engineering and operations research are two extensive technical fields which intersect to a considerable degree. At the outset of TAPPI activities in these fields, it was felt that the two should be examined jointly until a division between them suitable to the paper industry should become apparent.

As far as process industry is concerned, systems engineering is directed toward achieving the best arrangement of the elements of the process and the best control of these elements and of the material being processed, consistent with the objectives of the particular process unit. Such objectives may or may not include maximum "profitability" of the individual unit. The operating system chosen for study may be as small as a stock chest and its associated controls or as large as a complete kraft pulping operation.

Operations research in industry is characterized by great breadth of scope, usually the entire operation or company, and by preoccupation with the minimizing of costs or the maximizing of profits. Whereas systems engineering deals almost exclusively with the physical realm (except where reactions of human operators must be accounted for), operations research is often more concerned with human activity than the actual operation of machines. Marketing, procurement, and finance considerations frequently outweigh technical and production problems in operations research.

Both of these fields make extensive use of mathematical models of the systems under study and quite often employ automatic computation techniques in the solutions of problems and the manipulation of models. An extensive background of experience now accumulating in sister process industries should prove very valuable to those pursuing systems engineering and operations research work in the pulp and paper industry.

R-2. The Application of an Analog Computer to a Paper Manufacturing Problem, L. W. Zabel, Kimberley-Clark Corp., Neenah, Wis.

The machine direction temperature distribution on the surface of a Yankee drier manufacturing tissue has been calculated using the heat flow equation. This equation was solved on an analog computer by using the finite difference method. The partial differential equation was reduced to a set of 24 ordinary linear differential equations. The application of the special boundary conditions and data on driers made of two materials are given.

R-3. An Operations Research Approach to the Economic Balance of a Kraft Pulping Process, C. W. Carroll, The Institute of Paper Chemistry, Appleton, Wis.

Most operations research problems involve the mathematical description of complex industrial situations such that, by appropriate solution, those in charge of operations can make better decisions. The resulting mathematical statements describe how effectively a given set of operating conditions fulfills the objective: usually maximization of net dollar return. In addition certain realistic limitations nearly always apply.

The kraft pulping process, including the interrelated digester and recovery cycle operations, provides a self-contained system wherein an operations research approach to the economic balance is applicable. A realistic kraft pulping system constitutes the "complex" industrial situation" in this work. In order to develop the mathematical model, it is necessary to combine results of experimental studies on the kinetics of the kraft pulping operation with performance characteristics of the equipment involved and material and energy balances throughout the system. A rate expression is presented which, to within ±0.3%, relates total time of a cook to initial digester temperature, time-up-to-temperature, maximum temperature, sulphidity, initial chemical concentration, chemical-to-wood ratio, permanganate number, and total yield.

The model developed is of a very general and industrially important type. Its solution (optimization) could be accomplished by the combined application of two established operations research techniques: "The Method of Steepest Ascents" and "Linear Programming." However a new approach, which is expected to be of general utility, is presented.

The final phase of the research work was the development of a method of computation suitable for a digital automatic computer. The program accomplishing this and the results obtained using an IBM 650 computer are discussed.

Water Session I

S-1. Water Conditioning Trends in the Paper Industry, C. B. Houser, Cochrane Corp., Philadelphia, Pa.

The recent growth of the pulp and paper industry has been reflected in a sharp rise in power generation requirements and in boiler operating pressures. A vital part of the power plant is the boiler feedwater conditioning system.

Besides the increased quantity of water needed, the quality of the treated water must be improved for the modern, higher pressure boiler. The power plant operator is therefore faced with conditioning more water and frequently it must be of a higher quality effluent.

Recently, three pulp and paper companies were faced with this problem. Their case histories are given. The variables in each case were:

1. Quality of raw water

† Larocque, G., Axelrod, B., and Clark, S., "Measuring the printing quality of newsprint," *Pulp Paper Mag. Can.* 52, No. 3: 166–174 (Feb., 1951).

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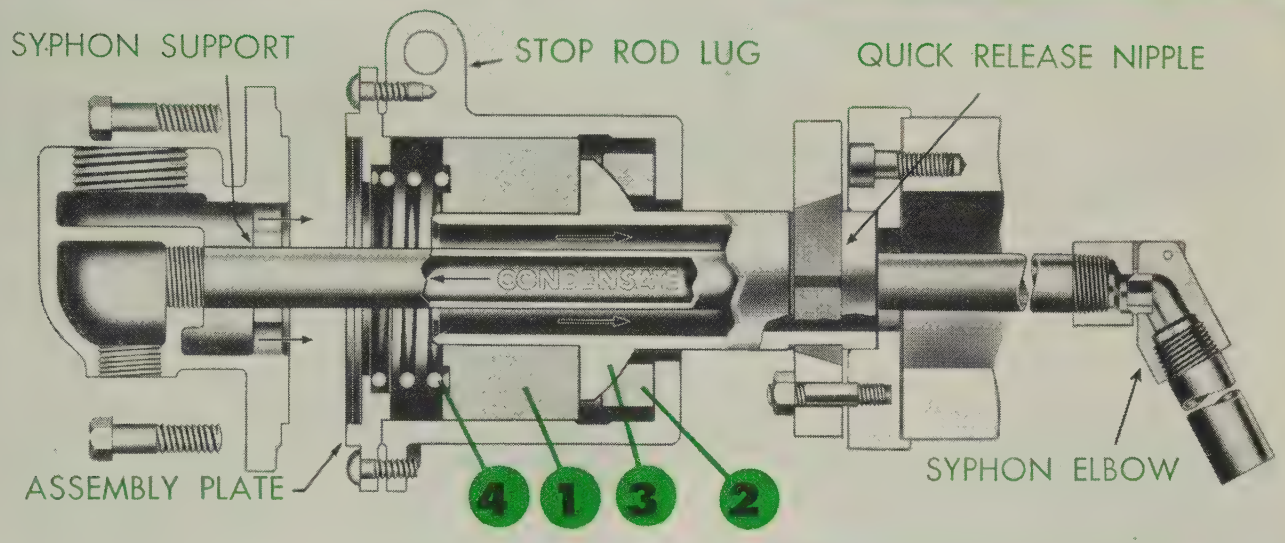

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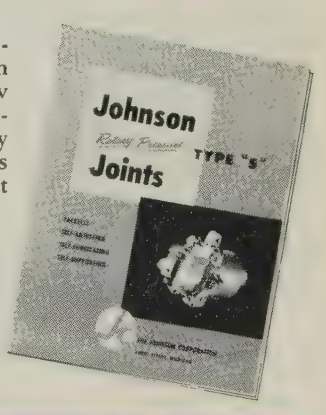

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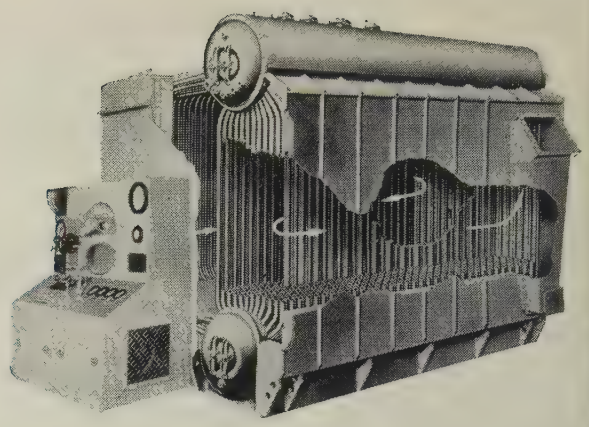
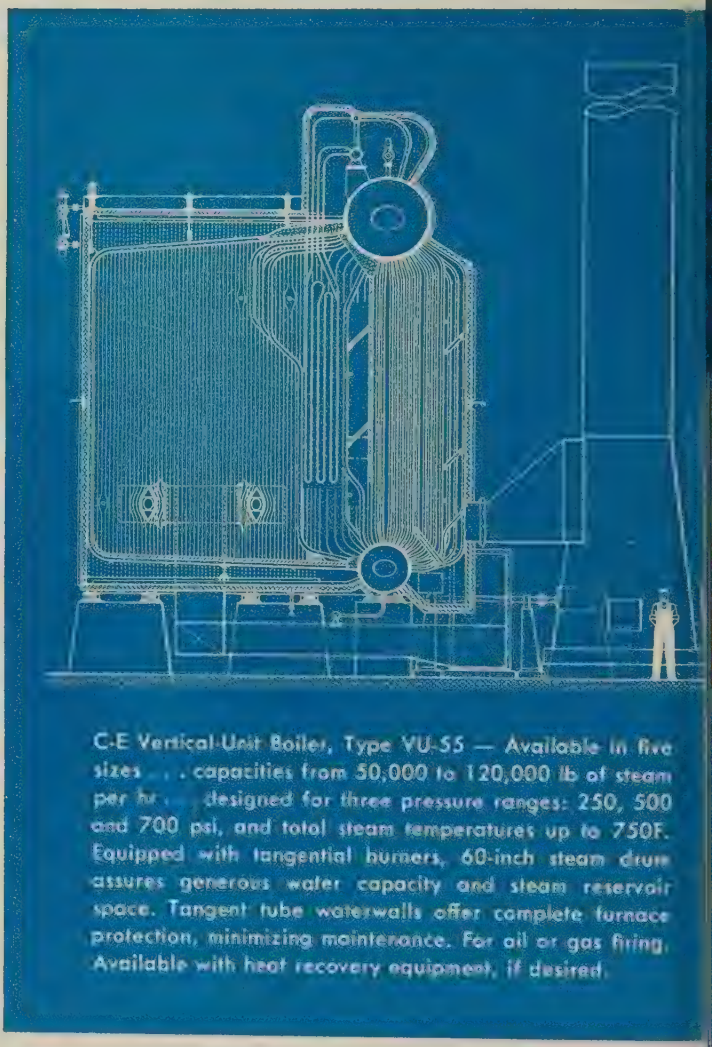


C-E Package Boiler, Type VP—Completely shop-assembled . . . available in 14 sizes from 4,000 to 50,000 lb of steam per hr capacity...pressures to 500 psi...available with integral console control panel. This unit contains more water-cooled area per cubic foot of furnace volume than any other boiler of its size and type. For oil or gas firing.



C-E Vertical-Unit Boiler, Type VU-55 — Available in five sizes . . . capacities from 50,000 to 120,000 lb of steam per hr . . . designed for three pressure ranges: 250, 500 and 700 psi, and total steam temperatures up to 750F. Equipped with tangential burners, 60-inch steam drum assures generous water capacity and steam reservoir space. Tangent tube waterwalls offer complete furnace protection, minimizing maintenance. For oil or gas firing. Available with heat recovery equipment, if desired.

C-E offers boiler designs for any pressure, temperature and capacity . . . for any fuel or combination of fuels. The units illustrated here include both standard and custom designs with capacities from 4,000 to 750,000 lb of steam per hr, with pressures to 1350 psi and steam temperatures to 950F. Two units are for oil or gas firing. The other four are available for coal, oil, gas or bark firing—either singly or in any desired combination. In addition to those illustrated, there are other designs available for more specialized applications.

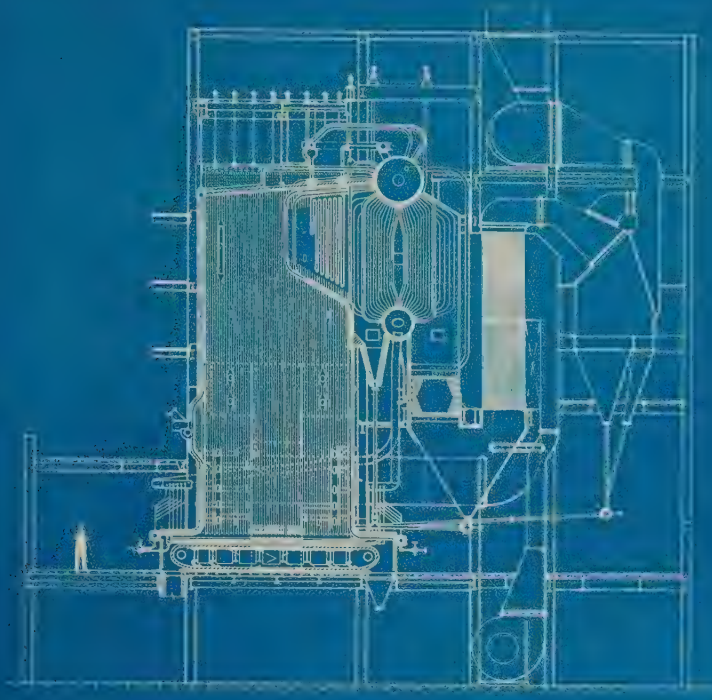
Whether you wish to add steam capacity to your present power plant — or build a single large boiler to meet all your steam needs — these units allow you a freedom of choice never before available. In addition to making full utilization of your bark supply, you can choose a supplemental purchased fuel best suited to the economics of your area for use when your bark supply is inadequate or your steam needs exceptional.

All these boilers have been proved in operation. They perform reliably and economically and — no matter what your combination of fuels or steam conditions — are designed to meet your needs exactly.

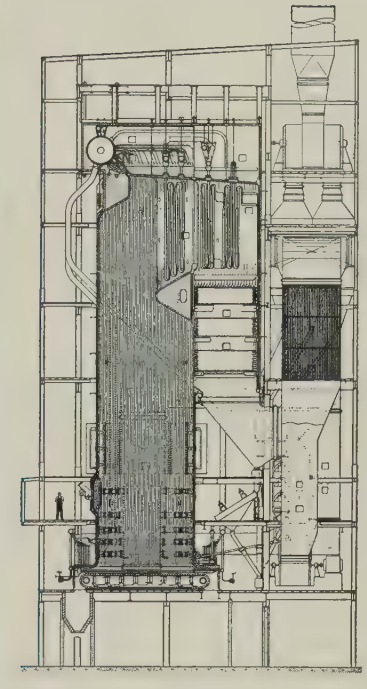
For further information, contact the C-E office nearest you. Or, if you prefer, write or phone the C-E Paper Mill Division in New York.

C-198

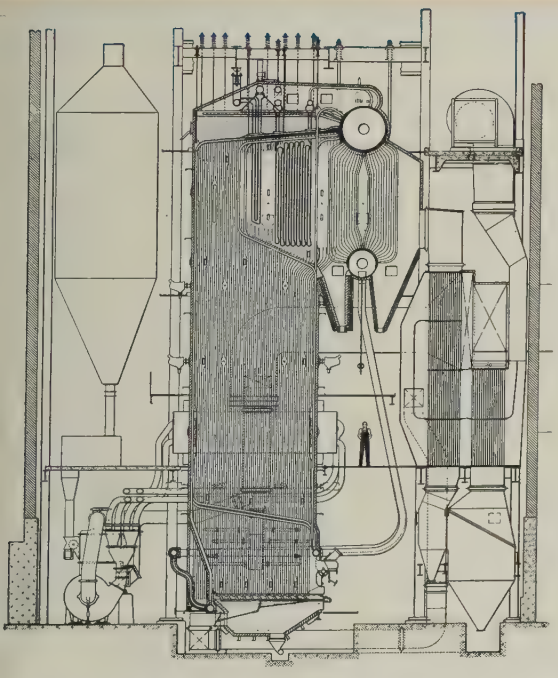
These drawings show but a few of the many types of C-E boilers available for pulp and paper mill use which burn two or more fuels. Not illustrated here is the C-E Chemical Recovery Unit.



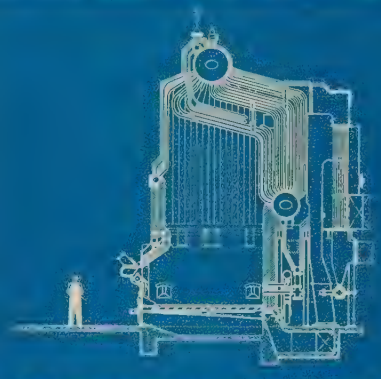
C-E Vertical-Unit Boiler, Type VU-40 — fired by C-E Tilting Tangential Burners and a C-E Continuous Discharge High Set Spreader Stoker. This unit is designed to burn natural gas, oil, coal and bark . . . a baffleless boiler with capacities ranging to about 300,000 lb of steam per hr with pressures to 1350 psi, temperatures to 950F.



C-E Radiant Type Boiler — Type RX — for bark, oil, natural gas, stoker or pulverized coal firing in any combination. Available in capacities to 750,000 lb of steam per hr, with pressures to 1350 psi and temperatures to 950F. The unit pictured is fired with a C-E Continuous Discharge High Set Spreader Stoker and C-E Tilting Tangential Burners.



C-E Vertical-Unit Boiler, Type VU-40 — for capacities to about 300,000 lb of steam per hr, pressures to 1350 psi and temperatures to 950F. For pulverized coal and bark firing, singly or in any combination. The unit illustrated is equipped with C-E Bowl Mills, C-E Tilting Tangential Burners and a C-E Dump Grate Spreader Stoker.



C-E Vertical-Unit Boiler, Type VU-10—fired by a bark and coal burning C-E Spreader Stoker. VU-10 Boilers are available for capacities to 50,000 lb of steam an hr, with pressures to 500 psi and temperatures to 650F. This unit type is available for coal, oil, gas or bark firing — singly or in combination

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2. Desired quality of treated water
3. Type and capacity of existing water treating equipment
4. Space limitations

Plant "A"

This company had a hot lime-zeolite plant. When plant de mand and boiler pressure increased, an automatic demineralization system for the new higher pressure boilers, was installed.

Plant "B"

This company had a two-stage hot process softening system. The first stage treatment was lime and soda ash followed by phosphate in the second stage. By operating the two sedimentation tanks in parallel and adding hot zeolite softeners, it was possible to increase the plant capacity by 50%, improve the effluent quality and decrease the cost of treatment at the same time.

Plant "C"

This company had a cold process coagulating clarifier followed by filters and zeolite softeners. This was replaced by modern cold process reactors, filters, and automatic demineralization sytem.

Studies of these three cases are given in detail. The data include:

1. Capacity, design and limitations of existing equipment
2. Alternate methods of treating each type of water considered
3. Equipment and operating costs
4. Conclusions

S-2. Diatomite Filters, J. G. Brown, Reversible Filtration and Granger Filters, Wakefield, Mass.

S-3. Quality of Water as It Affects the Pulp and Paper Industry, H. M. McFarlane, Abitibi Power and Paper Co., A. V. DeLaport and L. T. Vlassoff, Ontario Water Resources Commission, Toronto, Ont., Canada.

The literature on water quality as it affects pulp and paper production is reviewed. A short survey is made of water used in some widely scattered Canadian mills manufacturing a variety of products.

General Session I

U-1. Upgrading of Molded Pulp Products through the Use of Synthetic Resins, B. L. Carlson and F. Horowitz, Booty-Resinceers Div., American-Marietta Co., Seattle, Wash.

The use of new types of synthetic phenol formaldehyde resins produced marked improvements of physical properties of molded pulp products. Horticultural tests indicated no adverse effects by resin on various fruits. Installation of infrared equipment permitted economical and convenient production procedure. New and different applications for phenolic resins are indicated.

U-2. Adopting the Orphan of the Paper Industry, C. R. Stevens, Charles R. Stevens, Inc., Maumee, Ohio.

U-3. The Effect of pH and Alum Loading on the Activity of Polyacrylamide Type Flocculants in Papermaking Furnishes, J. L. Date and J. M. Shute, The Dow Chemical Co., Midland, Mich.

Laboratory work with polyacrylamide-type flocculants shows the performance of these polymers to be greatly effected in paper machine furnish by the alum loading and pH.

The use of these flocculants with proper alum loadings and within a certain pH range were found to greatly increase freeness and drainage rates of pulp. Increases of 200 to 300% in freeness values on pulp with an initial freeness of 100 ml. are achieved at very low polymer loadings.

Some light may be thrown on the mechanism of aluminum compounds in papermaking furnishes. Within the optimum pH range aluminum compounds apparently act as linking agents between the anionic fiber and organic matter and the comparatively nonionic acrylamide.

U-4. Electrically-Conductive and Static-Free Papers, M. Hayek, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Conductive organic chemicals should offer wide utility in the production of electrically conductive paper, needed for new duplicating processes, and in the control of static on paper in the paper and printing trades. Conductive treatments are an extension of antistatic treatments, the paper being made conductive along both surfaces and through the bulk of the sheet.

Static electrification occurs when two surfaces which have been in contact are separated and results from unequal affinities of the surfaces for electrons. An antistatic agent on paper adsorbs water and lowers the electrical resistance of the paper sufficiently so that little or no charge can accumulate at the point of contact of the paper sheet or web with a second surface.

Conductive treatments differ from antistatic treatments only in degree. The mechanism of action of conductive chemicals is identical to that of antistats.

In the laboratory, conductive chemicals are most conveniently tested by measuring the electrical resistance of treated paper at a controlled relative humidity.

The method of application of products to paper must be such that the chemical forms a continuous film over the cellulose fibers of the paper. Electron photomicrographs have shown differences in the nature of the deposit of chemical on the fibers after effective and ineffective treatments.

The agents can be coated or padded onto paper for conductive effects and, also, can be sprayed for antistatic effects. Several chemical types of conductive chemicals are effective. They reduce the electrical resistance of paper by as much as 10,000 times. To produce conductive paper for a particular use or to overcome a specific static problem, the treatment must be patterned to fit the needs of the particular situation. The behavior of a chemical depends upon the concentration and method of application of the agent and the nature of the paper.

Chemical Methods Session II

V-1. Progress Report on the Interlaboratory Testing of Pentosans Methods, W. K. Wilson and J. Mandel, National Bureau of Standards, Washington, D. C.

Three methods for the determination of pentosans, the TAPPI bromination method, the ASTM analine acetate method, and a modification of the Swedish orcinol method were compared in seven laboratories using 10 pulps. An over-all comparison of the three methods, based on the sensitivity criterion, shows that the orcinol method is probably superior to the other two methods.

V-2. A Nonhydrolytic Spectrophometric Method for Determining Lignin in High Purity Pulps, R. Bartunek, Vereinigte Glanzsotoff-Fabriken A.G., Oberbruch, Bez., Aachen, Germany.

The intensity of the yellow color developed by treating wood pulp with warm dilute nitric acid is used as the basis for determining "lignin number." During the past 33 years the decrease in consumption of viscose filter material has closely paralleled the decline in the lignin number of dissolving pulps. Ultraviolet spectrophotometric investigations on nitric acid extracts from various pulps showed that extenction maxima at 261 and 330–338 mmu were pronounced enough to allow differentiation between today's high-purity chemical pulps. It has been established that these maxima have their origin with the structural units of the lignin. Source of the 261 mmu maximum is the benzene ring while the 330–338 mmu maximum originates with the phenolic hydroxyl groups. Neither hemicelluloses nor extracties noticeably influence the reaction.

Chemical Products Session

W-1. Oxidation of Resin Acids of Pine Chips, R. V. Lawrence, Naval Stores Research Station, U. S. Department of Agriculture, Olustee, Fla.

There is a considerable difference in the composition of the resin acids extracted from pine wood chips and in the resin acid portion of pine oleoresin. Much of this difference is caused by the oxidation of the resin acids as they are exposed over the large surface area of the wood chips. The oxidation of the acids in the chips was quite rapid and in a few hours the levopimaric acid content was approximately one half that of pine oleoresin. When the surface area was decreased by extracting small blocks of wood instead of chips the concentration of the oxidized acids was greatly decreased.

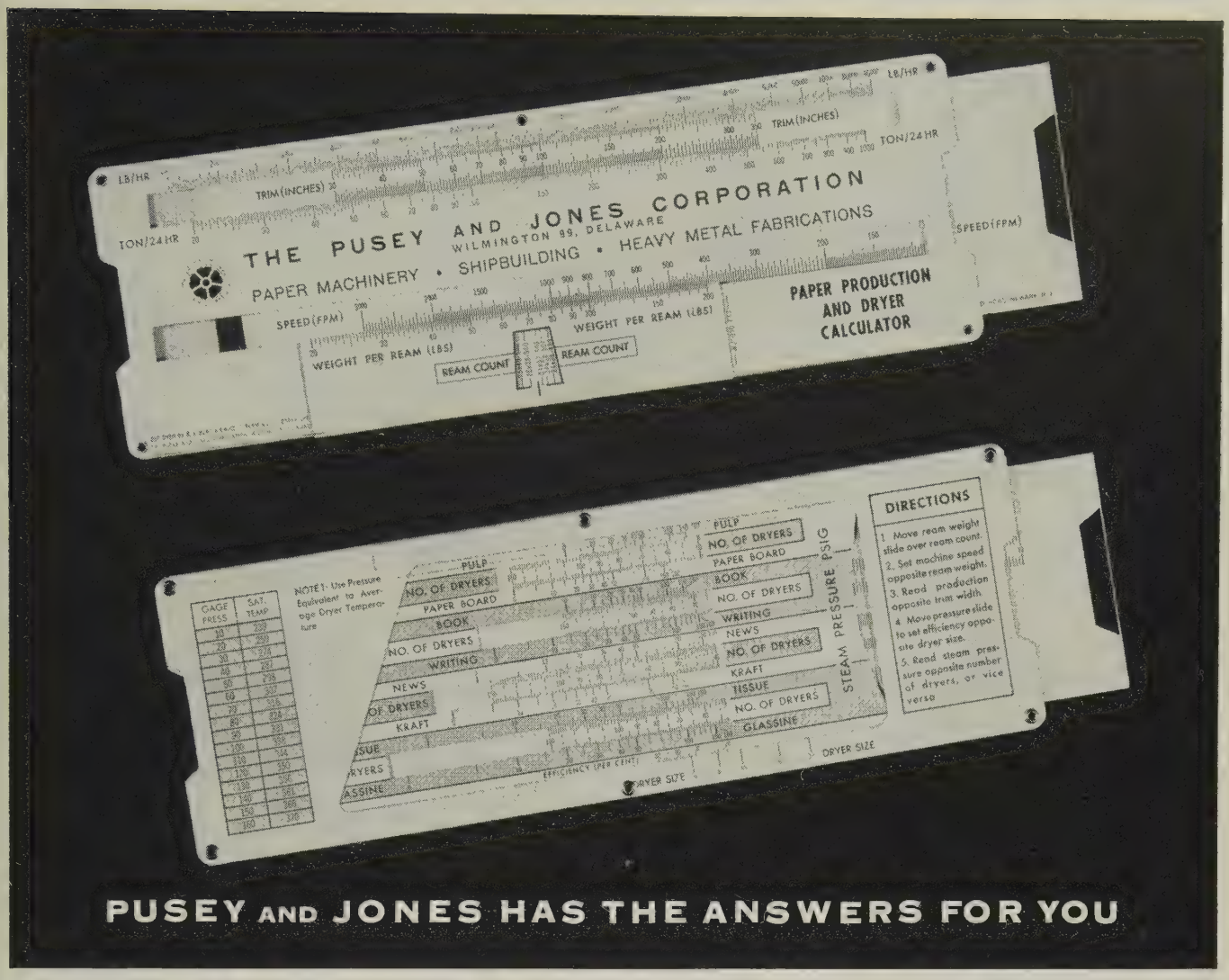
The oxidation products obtained indicated different types of oxidation occurred.

A study of the oxidation of some of the pure resin acids was carried out. Pure levopimaric acid was usually resistant to oxidation, but in the presence of light and a sensitizer it was rapidly oxidized. Several products were isolated and characterized from the oxidation of the pure acids. The conditions favoring the formation of some of these products were determined.

About 20% of the acids extracted from wood chips had been oxidized to some extent. Approximately the same amount of oxidized resin acids were present in black liquor soap.

W-2. Estimation of Tall Oil in Sulphate Black Liquor, W. Saltsman and K. A. Kuiken, Buckeye Cellulose Corp., Memphis, Tennessee.

Black liquor is diluted with water to dissolve the tall oil soap. A hydrogen peroxide treatment is used to oxidize inorganic sulphur compounds to sulphates. The solution is acidified and then diluted with a acetone-methanol mixture to redissolve precipitated lignin. Tall oils is recovered from this homogeneous system by extraction with low boiling petroleum ether. The extracted oil is dried and weighed.



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Equivalent ream weight	Both ream counts
Speed	Desired production, any ream weight-count combination and trim
Number of dryers needed in a new machine	Weight, ream count, speed, type of paper and steam pressure
Dryer efficiency in your present machine	
Extra dryers or increased steam pressure required in rebuilding for greater production, change of speed, different weight or conversion to another type of paper	

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W-3. Rapid Mixed Indicator Titration Method for the Determination of Rosin Acids in Tall Oil, E. H. Sheers and L. H. Stevenson, American Cyanamid Co., Stamford, Conn.

Work carried out in these laboratories showed the desirability of increasing the ASTM-prescribed reflux time from two to 15–30 min. and of using a Beckman Model K automatic titrator for the titration. This work led to the adoption of this method by the ASTM as its referee method.

The practice of titration of the alcoholic reaction solution to the two end points of Thymol Blue indicator is, however, still prevalent in industry, probably largely because many laboratories are not equipped with automatic titration equipment. Since our work showed that the equivalence points in this reaction occur at apparent pH values of 4.0 and 10.5 regardless of the tall oil sample used, and since Thymol Blue gives its second color change at an apparent pH above 11.0 in the alcoholic solvent used, it seemed desirable to work out an alternate indicator method which would give results in closer agreement with the potentiometric titration method.

A mixed Thymol Blue-2-naphtholphthalein indicator was found to change at an apparent pH of about 10.5 and thus gives results in reasonably good agreement with the referee method. Its use is, therefore, suggested for laboratories having no automatic titration equipment and for nonreference work.

Water Session II

X-1. Reversible Filtration of Paper Mill White Water, J. G. Brown, Reversible Filtration and Granger Filters, Wakefield, Mass.

This process has been evaluated for use in the clarification of white water saveall effluents with and without diatomite filter aid. The objective has been to produce a filtrate that can be used on high pressure showers, and in some cases this has bene superior to the fresh water supply. Test results have been obtained on a wide range of saveall effluents in five different paper mills.

The factors involved in the economical recovery of suitable recycle water were determined.

All data to date have been obtained on small plastic portable filters ranging in size from 6 to 48 sq. in. A new commercial Granger filter is now available that can handle up to 200 g.p.m. per filter.

Plans now call for the evaluation of 50 g.p.m. units on capacitor paper mill floatation saveall effluent.

X-2. Flotation Saveall Control Systems, G. Klebanoff, Jr., and C. G. Bueltman, The Permutit Co., New York, N. Y.

This paper describes control systems successfully used to obtain best economical control of new flotation saveall installations, and to improve the performance of existing installations. These control systems are designed for one or all of the following purposes:

1. To save additional fiber or pigment currently being lost in the plant effluent.
   This is particularly important if the recovered stock isre-
2. To improve the clarify of the treated whitewater by reused.
   moving more suspended solids, to enable its use in a higher priority function.
3. To decrease the pollution load if the white water is entering a public stream.
4. To decrease the number of man hours required for operation.
5. To minimize chemical feed dosages if such are being used.

X-3. The Role of Wire Retention in White Water Recovery, A. H. Tifft, Oxford Paper Co., Rumford, Me.

A study has been made of some of the factors affecting the loss of stock from the paper machine system. The degree to which single-pass wire retention is achieved is a major factor in the successful operation of saveall equipment, may affect the capital expenditure required for new savealls, and may affect the selection of the type of saveall required for a particular application. Good wire retention, by minimizing the concentration of tray water fines, tends to offset the adverse effects of white water system closure.

Basis weight, machine speed, furnish components, and wire retention aids affect wire retention. Selection of the best retention aid or combination of retention aids is a major factor in control of stock losses from paper machine systems.

A simple procedure for the determination of index of wire retention is presented together with data illustrating the principal factors affecting wire retention.

General Pulp Session

Y-1. The Distribution of the Constituents Across the Wall of Unbleached Spruce Sulphite Fibers, O. Kallmes,* The Institute of Paper Chemistry, Appleton, Wis.

The properties of fibers depend principally on their composition, their physical properties, and on the distribution of the constituents across the fiber wall. The first two factors have been studied extensively, but only a few distribution studies have been made and they were qualitative in nature.

A technique has been developed for isolating P-S_1 material and S_2 material from delignified fibers in sufficiently large quantities for chemical analyses. From the analyses of the P-S_1, S_2 material and the original fibers, it was possible for the first time to approximate the distribution of the constituents across the wall of unbleached spruce sulphite fibers. These distributions are as follows:

The concentration of lignin in P and S_1 (about 5.8%) is 10 to 20 times as large as in S_2 (0.4%). The concentration of alphacellulose (81.3%) and of the hemicelluloses (12.9%) in P and S_1 are slightly *lower* than in S_2 (82.6–84.0% and 15.5–17.0%, respectively). The distribution of the hemicelluloses is consistent with the distributions of the sugars, glucose, mannose, and cylose, which are present in an essentially constant ratio (29:2:1) across the fiber wall. The D.P. of P and S_1, 2030, is about two thirds of that of S_2. P and S_1 are partially crystalline, but not as much as S_2.

Two related experiments were carried out. (1) It was found that unravelled P and S_1 fragments can enhance sheet strength properties considerably. (2) Two theories on the "balloon-type" swelling were corroborated. These theories are that S_1 is primarily responsible for the constrictions observed during ballooning, and that the "skin substance" concept is unnecessary to explain ballooning.

Y-2. Sorption Studies of a Modified Locust Bean Gum on a Bleached Sulphite Pulp, A. Russo† and E. F. Thode, The Institute of Paper Chemistry, Appleton, Wis.

As a contribution to better understanding of the behavior of beater adhesives, the rate of sorption of a partially methylated locust bean gum (PMG) in a bleached sulphite pulp was intensively studied. In singling out the rate-determining factors, "infinite bath" sorption conditions were approximated; gum retentions were determined directly by use of a radiochemical tagging technique. Experiments were conducted to investigate the effect on the rate of PMG sorption of the variables time, PMG concentration, temperature, degree of agitation, and pulp specific surface area.

The observed experimental results demonstrated that the major rate-controlling factor in the over-all sorption phenomenon was a diffusional transport step bringing the gum molecules from the bulk phase of the solution to the surface of the fibers.

Y-3. Changes in the Fiber Structure of High Yield Pulps, R. Marton, Empire State Paper Research Institute, State University College of Forestry at Syracuse University, Syracuse, N. Y.

The changes in fiber structure which result from the mechanical separation of wood were examined under the microscope for mechanical and cold soda pulps prepared from a number of wood species. Photomicrographs were prepared from normal and cupriethylenediamine swollen fibers using both normal and polarized light. The rate and extent of swelling were observed and it was found that swelling was more pronounced and more uniform in pulps possessing the higher strength values. In contrast the lower strength pulps showed little tendency to swell even in those instances where good fiber separation was achieved.

The fiber structure of cold pulps was compared with those of spruce mechanical and chemical pulps. For the cold soda whole tubular fibers onto which fragments of the middle lamella adhered were seen and it was noted that the wall surfaces not covered with lignin showed that not only the primary wall but also a portion of the adjacent S_1 layer were detached. These same fractured surfaces were observed to undergo pronounced balloon swelling in cupriethylenediamine. In contrast spruce mechanical pulp exhibited few whole tubular fibers and high fractions of split fibers and fine structureless fragments. It did not show the quantity of exposed secondary wall substance to the extent noted for the cold soda pulps. The differences in fiber surface conditions were further reflected through beating; the cold soda pulp responded more favorably to strength development than spruce mechanical pulp.

The nature of fiber separation and the extent of fracture sustained by the primary wall is believed to exert a pronounced ef-

* Present address, Wiggins Teape Group Research Organization, Butler's Court, Beaconsfield, Bucks, England.
† Present address: W. R. Grace and Co., Paramonga, Peru.

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fect on the papermaking qualities of the pulps prepared by mechanical means.

Y-4. Distribution of Oxidant Consumption in Bleaching, J. H. E. Herbst and H. A. Kraessig, Industrial Cellulose Research Ltd., Hawkesbury, Ont., Canada.

When the number of bonds broken in the cellulose chains during bleaching is plotted against the amount of bleaching agent consumed, a straight line is obtained. The intercept and slope of this straight line are functions of the residual lignin content. The effects of a number of variables on the intercept and slope were investigated, and a discussion of the theoretical background and possible analytical applications is given.

Mechanical Pulping Session

Z-1. Effect of Condition and Kind of Wood on Groundwood Pulp Quality, E. R. Schafer, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, Madison, Wis.

Nearly all of the physical properties and conditions of wood resulting from growth environment and storage may affect the quality of the groundwood made from it. Different species of wood produce different qualities of groundwood because of characteristic differences in physical properties. This report reviews (a) properties and conditions of wood that have major effects on groundwood quality, and (b) the quality of groundwood that can be obtained from a few of the North American species and some foreign woods. Lower density woods are preferred for groundwood since they usually make stronger and longer fibered pulps. The main effect of heartwood is on the color or brightness of the pulp. Decayed wood may introduce dirt and lower yield but in general its effect on pulp strength and other qualities is not clear cut. Recorded histories of the changes occurring in pulpwood in storage and their consequent effect on groundwood quality are generally inconclusive and often conflicting. Differences in the groundwood pulp obtained from dead and live timber, if any, are attributable to the causes of death and subsequent destructive agencies and not to the fact the wood is dead. Green or rewetted wood generally produces better quality groundwood than seasoned wood. The effects of other properties and conditions are discussed. Spruce groundwood pulps rank highest among other softwood groundwoods in fiber length, strength, and brightness. Among other softwoods, all the North American pines for which data are available are suitable for groundwood pulping insofar as strength is concerned. Aspen is the most important hardwood used because of its low density, light color, and abundance. Groundwood made from higher density hardwoods generally contains a high proportion of fines and has low strength. The strength of hardwood groundwood can be improved by pretreating the logs with chemical solutions. Typical groundwood pulp data for a number of species are included in the report.

Z-2. Survey of Groundwood Wet Web Strength Testing, M. Htoo, International Paper Co., Glens Falls, N. Y.

Z-3. Pretreatment Effects on Peroxide Bleaching of Groundwood, I. C. MacGugan, Becco Div., Food Machinery & Chemical Corp., Buffalo, N. Y.

Pulp Purification Session

AA-1. Physical Properties of Bleached High-Yield Pulps, N. N. Coe and H. L. Crosby, Dorr-Oliver, Inc., Stamford, Conn.

A black birch pulp prepared in close to a 100% yield by a chemimechanical process was bleached with (1) sodium hydrosulphite, (2) peroxide, (3) chlorine dioxide, (4) sodium hypochlorite, and (5) chlorine with a caustic extraction following. Beater evaluation showed that the first four bleaches resulted in slightly improved burst, tear, tensile, and apparent density, and slightly poorer opacity as compared to the unbleached pulp. However, the chlorine-caustic bleach was very significantly higher in burst, tear, tensile, and apparent density and much lower in opacity. In brightness gain, yellowness reduction, and cost per point of brightness gain sodium hypochlorite appeared most favorable.

AA-2. The Effect of Pulp History on Pulp Response during Hypochlorite Bleaching, J. C. Paulson, Buckeye Cellulose Corp., Memphis, Tenn.

The reaction between sulphate pulp and hypochlorite may be simplified by treating it as a cellulose depolymerization reaction with the lignin and hemicellulose fractions competing for hypochlorite usage. Thus, the effects of pulp history and the accompanying changes in the lignin and hemicellulose fractions are shown by the sparing action on the cellulose fraction. The change in cellulose D.P. is estimated by measuring the change in pulp fluidity per unit of hypochlorite consumed, $d\Phi/dx$. A further simplification is gotten by splitting the total reaction into two parts, the so-called initial rapid reaction and the slow reaction. The magnitude of the initial reaction depends upon the amount of lignin in the pulp, and, with lignin the main substrate, there is only a slight influence on cellulose D.P. During the slow reaction the pulp fluidity increases as a linear function of the amount of bleaching agent consumed; however, the magnitude of $d\Phi/dx$ is influenced by two competing substrates, the amount of lignin solubilized during the initial reaction and the amount of hemicellulose in the pulp.

AA-3. Oxidation of Some Simple Organic Molecules with Aqueous Chlorine Dioxide Solutions, R. A. Somsen, The Institute of Paper Chemistry, Appleton, Wis.

Diacetyl and 2,3-butanediol were oxidized with dilute aqueous chlorine dioxide solutions buffered at pH 1. Isolation of acetic acid and carbon dioxide as reaction products from each of these compounds showed that there was carbon-carbon cleavage during the chlorine dioxide oxidations resulting in the formation of carboxyl groups and carbon dioxide. The experimental results have been related to the chlorine dioxide oxidation of cellulose.

AA-4. Pulp Bleaching with Sodium Chlorate, W. H. Rapson, C. B. Anderson, and R. W. Millen, University of Toronto, Toronto, Ont., Canada.

The direct use of sodium chlorate for pulp bleaching without first converting it into chlorine dioxide would save a great deal of capital and operating cost in pulp bleaching plants. Sporadic attempts to do this over several years are reported.

Sodium chlorate bleached pulps in strongly acid solutions, but the latter seriously degraded the cellulose. By using vanadium pentoxide as a catalyst, the acidity required was greatly lowered, but the hydrolytic attack on the cellulose was still serious under practical bleaching conditions (13% consistency, pH 2, 70°C., 4 hr.). "Activated chlorate," supplied by Azienda Brevetti Industriali of Milan, Italy, gave similar results. The conditions (time, temperature, consistency, ratio of vanadium oxide to chlorate, and ratio of chlorate to pulp) were varied systematically and brightness, color stability, viscosity, and hot alkali solubility were measured.

While catalyzed sodium chlorate bleached sulphite pulp and partially bleached sulphate pulp reasonably well, it did not bleach unbleached kraft pulp or unbleached semichemical pulp directly.

Adding uncatalyzed sodium chlorate to the chlorine in the chlorination stage, as recommended by Heitman, had a negligible effect on pulp brightness, but in certain cases a slightly higher viscosity was noted.

By using very high consistency at room temperature with catalyzed acidified chlorate, as recommended by Marpillero, the rate of degradation of cellulose was lowered. With very long bleaching time (2 to 14 days at 23°C.) good bleaching of partly bleached pulps was accomplished, with only a little degradation.

In all direct comparisons made in this investigation chlorine dioxide gave higher maximum brightness with much less than the equivalent amount of sodium chlorate with no significant degradation of the pulp. Therefore, unfortunately, conditions have not yet been found under which sodium chlorate can displace chlorine dioxide for pulp bleaching, either cost-wise or quality-wise.

AA-5. Evaluation of Brightness Changes in High-Yield Pulps Treated with Sodium Borohydride, P. Luner, Empire State Paper Research Institute, State University College of Forestry at Syracuse University, Syracuse, N. Y.

This investigation describes work conducted on the brightness of high-yield pulps. Special reference is given to the origin of color in white birch cold soda pulps, methods of characterizing color and brightness changes and the reduction of cold soda pulps with sodium borohydride.

The deep red-brown characteristics color developed by the action of alkali on white birch results from the interaction of oxygen and quinoid type structures. The latter may arise via peroxide formation of the lignin when wood is exposed to air.

Methods of characterizing the brightness changes in pulps are discussed with reference to data obtained from sodium borohydride reduced pulps. These data include difference reflectance spectra, post color numbers, and rates of brightness reversions. The findings using similar techniques on other wood species and with other bleaching agents are reported.

AA-6. The Mechanism of the Acidic Chlorination of Lignin and Lignin Model Compounds, C. Dence, Empire State Paper Research Institute, State University College of Forestry at Syracuse University, Syracuse, N. Y.

The mechanism of the acidic chlorination of lignin model compounds and spruce lignosulphonic acid has been elaborated by means of a combination of spectrophotometric techniques and classical organic chemistry. Substitution of chlorine into the 6-position during chlorination in an aqueous system of pH 1 has

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been demonstrated photometrically by reaction difference spectra to be the initial reaction. Further reaction with chlorine causes the carbinol side chain of veratryl and vanillyl alcohols to be replaced by chlorine resulting in the formation of 4,5-dichloroveratrole and 4,5-dichloroguaiacol respectively. Lignin model compounds possessing functional groups such as —CHO, —CH_2SO_3Ba and —$CH_2CH_2CH_3$ in the 1-position appear resistant to cleavage by chlorine. Alkoxy compounds such as the methyl ether of veratryl alcohol and the dimethyl ether of pinoresinol undergo the cleavage reaction to form 4,5-dichloroveratrole but to a much smaller extent. This cleavage reaction conceivably is operative in the chlorination stage of the bleaching operation and results in the degradation of the lignin polymer.

By means of ionization difference spectra demethoxylation has been shown to occur simultaneously although less rapidly than the side chain cleavage reaction. The ionizaion difference spectra of these reaction mixtures possess a peak at 320 mmu which is characteristic of synthetically prepared chlorocatechols and chloroguaiacols.

The behavior of spruce lignosulphonic acid toward chlorine is best rationalized on the basis that there is present a mixture of sulphonated and unsulphonated α-hydroxy-guaiacol and α-hydroxyveratryl units.

The ionization difference spectrum of the aqueous extract of chlorinated Norway spruce wood bears a close similarity to that of 4,5-dichlorocatechol suggesting a mechanism similar to that found for the model compounds.

General Session II

BB-1. New Aluminum Pigment Systems for Water-Base Paper Coating Application, A F. Knoll, Metals Disintegrating Co., Elizabeth, N. J.

A procedure, recently patented, for obtaining inhibition of gas formation of aluminum pigment in water base coatings is described. The procedure is applicable over a pH range of approximately 3 to 9 with variety of latex and other film forming vehicles. Practical stability of a year or more has been obtained.

A water dispersible organic solvent thinned aluminum paste is described also. This paste yields coatings on absorptive surfaces of excellent water resistance, adhesion, and brightness.

The application of both of these developments to paper coating is discussed.

BB-2. A Practicable Approach to Utilization of Solids from Deinking Mill Effluent, A. H. Nadelman and L. P. Newton, Western Michigan University, Kalamazoo, Mich.

BB-3. Improved Methods of Testing Remoistenable Gummed Sealing Tape, C. E. Roberson and W. B. Roberson, Hudson Pulp and Paper Co., Palatka, Fla.

TAPPI's tentative test method for determining the adhesiveness of gummed paper tape (T 463 m-52) is critically reviewed and a method of wetting or activating the gummed tape by spraying water on the glue surface in place of a conventional tape dispenser equipped with a brush and water tray is presented. A much greater reproducibility of test results is obtainable. The method presented also permits studying the performance of tape with varying quantities of water and various holding times after wetting which cannot be readily done with the conventional method of wetting tape.

BB-4. Cyanoethylation as a Means of Improving the Dimensional Stability of Paper, J. L. Morton, International Business Machines Corp., Endicott, N. Y., and N. M. Bikales, American Cyanamid Company, Stamford, Conn.

An investigation of the properties of cyanoethylated paper was made with particular respect to dimensional stability. It was found that a substantial improvement in dimensional stability results when cyanoethylation is carried out on the pulp, rather than on preformed sheets. The improvement is proportional to the degree of cyanoethylation when substitution is carried out in the range where morphology of the pulp is unaffected. In blends of cyanoethylated and untreated pulps, the expansivity is directly related to the ratio of the amounts of treated and untreated pulps in the blend. The improvement in dimensional stability is the result solely of etherification with acrylonitrile, as indicated by the fact that a control treated with alkali only showed no decrease in expansivity.

A new process of cyanoethylation is described, involving the use of minimal quantities of both sodium hydroxide solution and acrylonitrile.

Microbiology Session

CC-1. Microbiology of the Purification of Polluted Waters, H. Henkelekian, Rutgers, The State University, New Brunswick, N. J.

CC-2. A New Technique for the Evaluation of Paper Mill Toxicants, A. M. Stern, West Virginia Pulp and Paper Co., Covington, Va.

In the past, work on slime control has followed two separate lines of investigation—development of a means of early diagnosis of slime infestations and a search for suitable means of evaluating biocides. Thus far, neither approach has met with any startling success. The present report is the beginning of what is considered to be a significant break-through in both problems.

The operating concept of this new technique is to simulate, as nearly as possible, mill conditions and still allow for enough flexibility to make it practical to run large numbers of tests within the confines of a normal laboratory. Thus, our contact environment is mill white water that has been sterilized to afford greater experimental control but in such a manner as to permit it to maintain its chemical integrity. The inoculum is a mixed "culture of slime" that is obtained at the same time and from the same site as the contact medium. Environmental conditions such as pH, temperature, and degree of aeration are adjusted to those existing at the sampling site. The analysis itself involves the quantitative measurement of the amount of slime built up on the end of a receptor stick inserted into the contact environment during the full course of the incubation period. Additional information is derived from a qualitative estimate of surviving microbial populations.

Included with a detailed series of slides illustrating the new method are data of experimental runs designed to determine the effects of such variables as inoculum size, length of incubation, replication, and dosage levels of various biocides.

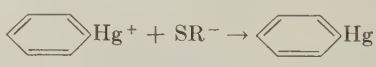
CC-3. Paper Manufacture Under Sterile Conditions, N. Alper, Chemical Research Laboratories of America, Inc., Lafayette, R. I.

CC-4. Di-(Phenylmercuric)-Ammonium Propionate—A New Slime Control Agent, S. J. Lederer and W. J. Delaney, Metalsalts Corp., Hawthorne, N. J.

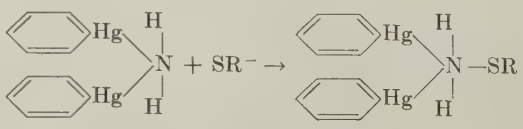
An extensive screening program was carried out with several hundred new organo-mercurials in an effort to find more effective slime control agents. A preliminary chemical and physicochemical study resulted in the rejection of many of the available compounds because of undesirable properties such as color or odor which might be imparted to the pulp and paper.

A series of very effective antimicrobials, the di-(phenylmercuric)-ammonium salts, were prepared which differ markedly from the various types of organomercurials which had previously been investigated. These compounds contain a stable quaternary ammonium complex in which the mercury is securely tied to the nitrogen. The strength of this complex was demonstrated by its ability to form salts with all active hydrogen compounds ranging from the strong inorganic acids like hydrochloric to the weakly acidic enol ethyl acetoacetate. These complex salts were 10 to 10,000 times more water soluble than the corresponding phenylmercurials which have been widely investigated as slimicides.

If one examines the widely accepted mechanism of biological action of mercurials it can be seen that the phenylmercurials, for example, combine with the sulphydryl (SH) groups present in living organisms to form stable mercury-sulphur linkages as shown by the following equation:



The di-(phenylmercuric)-ammonium salts cannot form a direct mercury-sulphur linkage because of the complex and must consequently react to form the much weaker nitrogen-sulphur linkage.



The very high order of antimicrobial activity of the di-(phenylmercuric)-ammonium salts can be attributed in part to decreased deactivation in the presence of interferring materials such as sulphides and mercaptans.

Microbiological results indicated that the di-(phenylmercuric)-ammonium acetate, propionate, and methacrylate were con-

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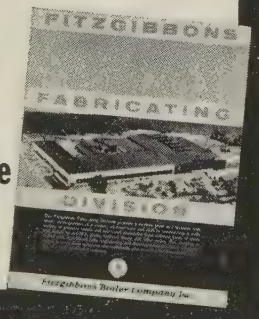

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siderably more effective against the slime producing organisms than the corresponding phenylmercurials. Di-(phenylmercuric)-ammonium propionate was selected for plant trials because of a combination of very high slimicidal activity and water solubility making it available for use as a solid or liquid preparation.

Tests were carried out in two paper mills with di-(phenylmercuric)-ammonium propionate run in comparison with phenylmercurial preparations which had been used for several years. In both cases the di-(phenylmercuric)-ammonium propionate proved to be considerably more effective as a slime control agent. This confirms, under actual plant conditions, the laboratory data which had shown di-(phenylmercuric)-ammonium propionate to be one of the most powerful slimicides yet prepared.

Structural Fibrous Materials Session

DD-1. The Measurement of Compressibility as a Factor in Evaluating Experimental Stock Furnishes for Insulation Board Manufacture, E. J. Reichman, Simpson Fiber Co., Seattle, Wash.

The consistent mathematical relationship between dryness of insulation board wet lap and the pressure applied in its formation can be utilized to predict the operability of a stock furnish on a commercial board former. This relationship can be expressed by an equation of the type $y = ab^x$, where y equals per cent over dry, a is a constant, and b is the pressure applied to the wet lap during its formation. The values of the expression are practically independent of the raw material or the degree of pulping refinement. The relationship between the dry density and the pressure applied to the wet lap also fit this type of mathematical expression but the values of a and x are variable depending upon the raw material and the pulping treatment. These values can be determined by recording the pressure applied to laboratory test boards, the resulting dryness of the wet lap, and the density of the test board after drying. The relationships will plot as linear functions on log-log graph paper and by defining the parameters of acceptable wet lap dryness and desired product density, the laboratory results will predict the operability of an experimental furnish on a commercial board former.

Caliper of laboratory test boards can be effectively controlled by regulating the thickness to which the pulp matt is compressed in formation. The effects of quantity of pulp and the degree of refining are minor and will differ appreciably with various types of raw material.

DD-2. Self-Heating of Wood Fiber, K. N. Smith, Johns-Manville Corp., Manville, N. J.

Wood fiberboards, made from 10 species of hardwoods and softwoods, were tested for benzene-alcohol extractable content and for rate of self-heating. Self-heating is defined as the increase in temperature of a material above the temperature of its surroundings owing to an exothermal reaction occurring within the material.

The self-heating rate was determined by heating a cubical sample of fiberboard to 325°F. in a specially constructed furnace. As the temperature of the fiberboard increased because of selfheating, the temperature in the furnace was maintained 0.5°F. below that of the fiberboard to contain most of the generated heat within the sample.

The extractable content of the wood fiber was determined according to TAPPI Standard T 6 m-54, with a few minor changes.

The results disclosed that the alcohol-benzene extractable portion of the wood was apparently responsible for the exothermic reaction, and the rate of reaction increased linearly with the, amount of extractable material. Two correlations were found, one for hardwoods and northern softwoods, and one for southern softwood.

DD-3. The Evaluation of Fibers for Insulating Board—A New Approach, J. d'A. Clark, Consultant, Victoria, B. C., Canada.

The various physical properties of insulating board are discussed in relation to the length, fineness, cohesiveness, wet flexibility, and intrinsic strength of its components. Of these, fiber length, fineness (slenderness), and cohesiveness of the elements are the important properties and these are discussed in detail. Because a board is a three-dimensional, rather than a two-dimensional structure like paper, for which these variables have been previously studied, further experimental work is evidently needed. The use of viscose fibers of widely different deniers and lengths, bound together with various quantities of beaten pulp, with which to make test boards, is suggested as a simple and straightforward way of ascertaining the desired relationships, which presently can only be inferred by analogy. Such data would be most valuable, not only to characterize new materials, but also to improve means for preparing the stock for boards.

DD-4. Latest Trends in Raw Material and Process in the Insulation and Hardboard Fields, L. Eberhardt, Bauer Bros. Co., Springfield, Ohio.

The insulation and hardboard industry has grown from two plants, producing less than 100 tons per day in 1925 to an industry of some 40 plants, producing nearly 8000 tons per day in 1958.

Early raw materials were bagasse, straw, poplar, and southern pine. Processes involved were adapted from the paper and plywood industry, i.e., mechanical grinders and the multideck drier. Some innovations were developed like exploded wood.

There has been an increase in the utilization of hardwoods and wood waste in recent years. The former has increased the use of chemicals and the latter has presented problems in the wood room due to contamination and nonuniformity.

New automated processes have been developed, equipment has been improved, and today, highly efficient versatile multipurpose plants are possible.

Groundwood from chips, cold soda pulps, and steamed wood are processes that look particularly promising.

Impact, dirt and continuous wear all gang up on pulp wood and barking drum chains, often with costly results. However, tough TISCO manganese steel chains actually get harder through constant pounding, and outwear ordinary chains 5 to 1. Insist on long-lasting TISCO pulp wood chain and barking drum chain for steady, profitable production. To get complete details write to:

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DIVISION OF HARSCO CORPORATION
Established 1742
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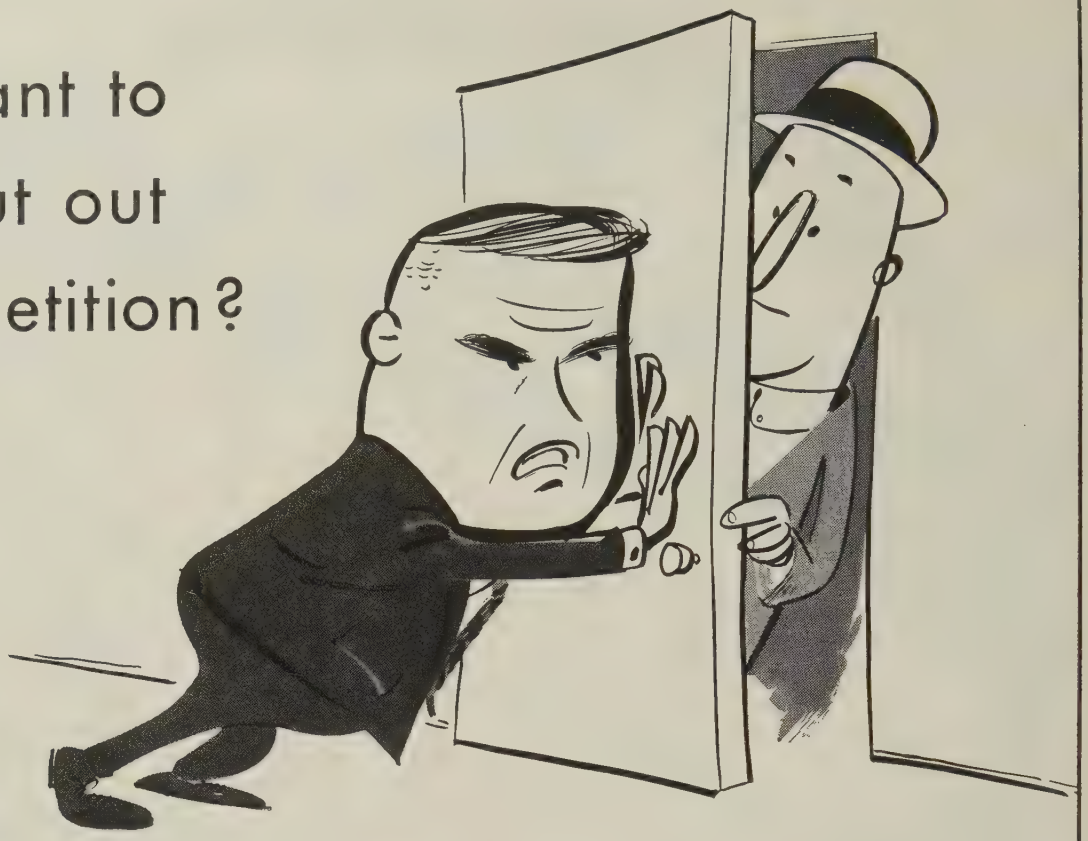
PLANTS: Cincinnati, O. — Birmingham, Ala. — Easton, Pa.
SALES OFFICES: New York — Chicago — San Francisco

Want to shut out competition?



Investigate new PURECAL*O

— Wyandotte's *refined* grade of pure calcium carbonate

When coating quality must be improved to let you slip in *ahead* of competition, call for Wyandotte's new *Purecal O*. Here's why:

A calcium carbonate precipitated by an exclusive process, aggregate-free *Purecal O* has unique physical properties. So it's ideally suited for high-speed, "on-the-machine" coating, where high-solids coating mixtures are so important.

Withholding water to increase solids content normally causes the viscosity of the mixture to increase too rapidly, making it putty-like in consistency. But pigment slips made with *Purecal O* can have desired high-solids concentrations . . . still retain the low viscosity essential to successful high-speed coating.

Get full information on Wyandotte's new *Purecal O* . . . and find out how it can help you make a *better* sheet to sell at *competitive* prices. For technical data and samples to evaluate in your laboratory, write: *Wyandotte Chemicals Corporation, Technical Inquiry Section, Wyandotte, Mich. Offices in principal cities.*

WETS OUT FASTER, DISPERSES BETTER

New agglomerate-free *Purecal O* wets out in one-fifth the time; disperses fast, *without* prolonged kneading to break down aggregates.

SIZED FOR MAXIMUM HIDING POWER

At 0.25 micron, particles of *Purecal O* have maximum hiding power; provide *extra* gloss and sheen without sacrificing opacity.

*REG. U.S. PAT. OFF.

Other Wyandotte products for the paper industry:

SODA ASH • CAUSTIC SODA
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WYANDOTTE CHEMICALS

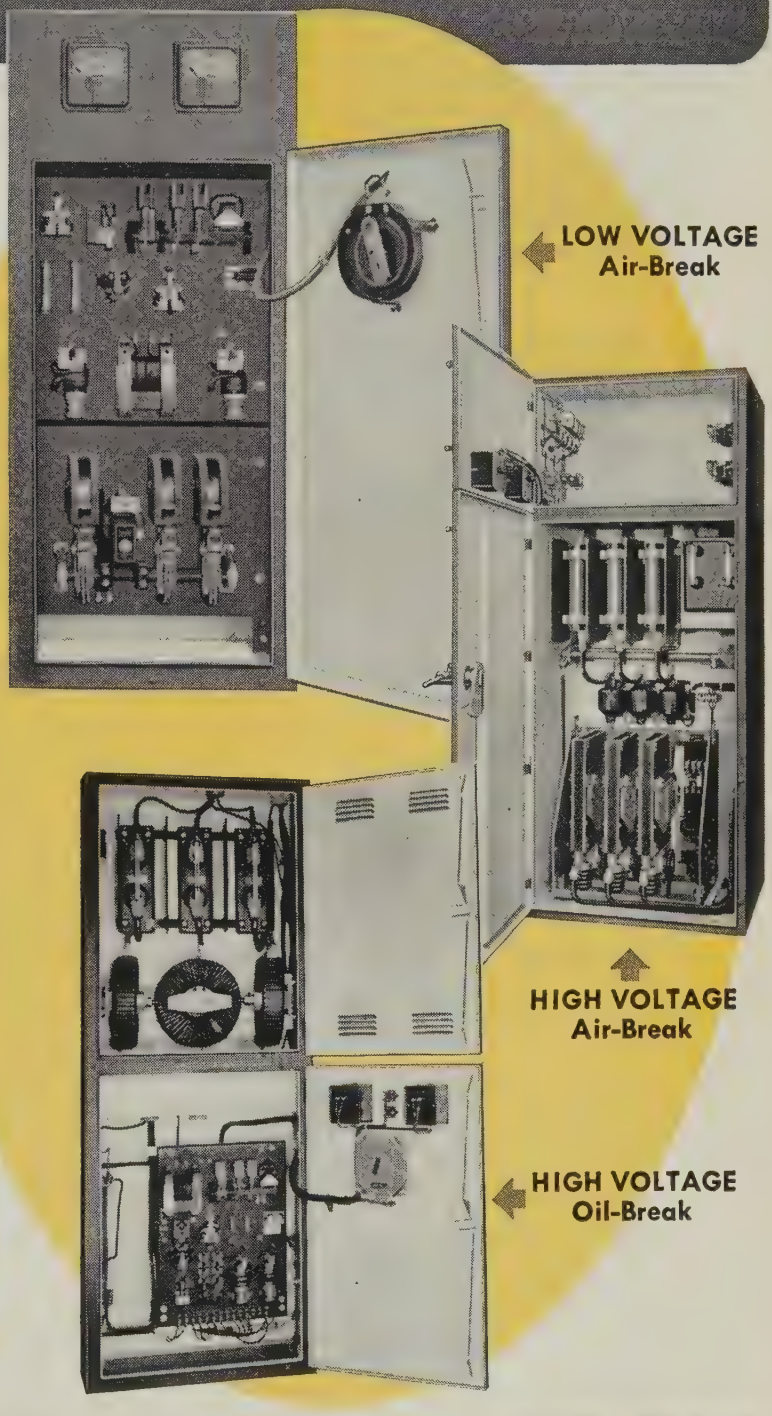
Wyandotte CHEMICALS

MICHIGAN ALKALI DIVISION

PACING PROGRESS WITH CREATIVE CHEMISTRY

IT'S EC&M FOR A COMPLETE LINE OF SYNCHRONOUS MOTOR STARTERS!

FOR ALL LOW VOLTAGES AND FOR 2200-4800 VOLT POWER SYSTEMS!



Here's Why EC&M Pushbutton Automatic Starters Do The Job Better...

Complete protection during starting, acceleration and while running at synchronous speed.

Motor pulls into step without delay because field is applied under best conditions for synchronization.

Automatic field removal and re-synchronization allow motor to accelerate and re-synchronize after voltage dip or momentary overload.

Easily installed because all internal wiring is complete.

Full or reduced voltage starting All high voltage starters available in 3 ratings: (*1*) 50,000 KVA (certified) interrupting capacity—(*2*) with power-type, current-limiting fuses —(*3*) VALIMITOR® (volt-ampere-limitor), the bus may be of unlimited KVA.

Write for Bulletins 8200 and 8820

THE ELECTRIC CONTROLLER & MFG. CO.
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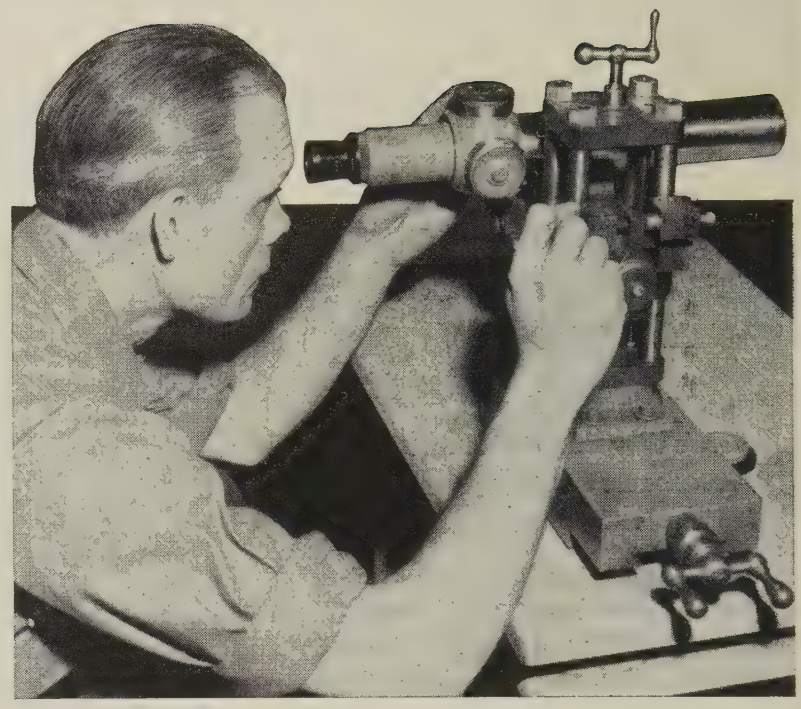
Building the skill of experience into

LODDING DOCTORS...



Herbie Mattson has inspected 10,000 doctors. Through his alignment telescope, Herbie has peered at these doctors, making sure that each one comes within the critical tolerances necessary for good doctoring. Any deviation from Lodding's high standard is immediately detected. It is because of such meticulous care as this that Lodding is able to guarantee the fit necessary for satisfactory operation of Lodding Doctors.

The high performance which everyone expects and receives from Lodding Doctors is the result of the care and experience of the team producing them. This is an asset which only comes in specializing in doctors over the years.

During the last ten years, Lodding has made more than 10,000 doctors, 17,000 blade holders and 350,000 blades. Lodding shares this experience with you.

LODDING ENGINEERING CORPORATION
WORCESTER, MASSACHUSETTS

WAUSAU SEVEN YEARS AFTER

First midwestern mill to use Ammonium Bisulfite Pulping reports big saving in costs; "would never go back to calcium-base process."

Seven years ago Wausau Paper Mills converted its big pulp mill at Brokaw, Wisconsin to Ammonium Bisulfite Pulping—the first mill in the Middle West to adopt this process. What does Wausau think of A.B.P. after seven years of experience? David Smith, president and general manager, sums it up this way: "Now that we've used ammonia, we'd never go back to lime."

Cooking Time Down, Yield Up

Although acid made by A.B.P. is a little more expensive than with the calcium-base process, this cost was more than offest by the shorter cooking time required with ammonia. This has reduced the cost of steam per ton of pulp, at the same time permitted an increase in output. Wausau's three digesters were cooking 85 tons a day with the calcium process. Now they produce 100 tons a day, could turn out even more if the need arose.

Yields from the wood itself have gone up, too, because there are fewer rejects during screening. These used to run 3 or 4%, now average about 1%, depending on the wood used, number of knots, etc.

Ammonia has also given the mill wider choice of pulpwoods. Almost any species can be used—soft woods such as spruce, hemlock, tamarack, larch and balsam; hardwoods such as birch and maple.

Less Maintenance

At Wausau the switch to ammonia has eliminated entirely the maintenance problems associated with "liming-up." Strainers haven't clogged up once in seven years. Previously, they had to be cleaned every three months, while acid and relief lines required attention at least once a month. The company says that digester room maintenance has been reduced since they converted to A.B.P.

Easier Pollution Control

The unpopularity of pulp mills with their down-stream neighbors has engaged legislative attention in most of the paper-making states. This was another consideration in Wausau's decision to switch to ammonia. Pulping wastes from the process can be evaporated or burned, need not be fed into streams to cause pollution. (Wausau ponds its spent liquor on an island, but with some additional capital investment it is possible for mills to recover it.)

Conversion Was Easy

Allied Chemical's Nitrogen Division, which pioneered Ammonium Bisulfite Pulping, helped Wausau plan the conversion of its lime pulping unit to ammonia, and Allied engineers worked closely with Wausau's staff to put the new process onstream.

Three inter-connected storage tanks were built. Two of the tanks hold anhydrous ammonia. The third, used for mixing, contains aqua ammonia at a maintained concentration of 20%. A new absorption tower for acid making was constructed. It is lined with tile and filled with layers of Raschig rings, over which ammonia trickles down while gas flows up. Some sulfite mills have converted their Jennsen towers to ammonia absorption duty by lining them, but Wausau found it more economical to build a new unit.

Automatic controls eliminate all guesswork and permit concentration of acid to be held constant or, when desired, quickly changed.

Trend to A.B.P. Seen

Today, about 16 mills are using the Ammonium Bisulfite Pulping process in the U. S. and Canada for acid-making. Allied Chemical has helped many of these mills with technical counsel and, as a leading ammonia producer, supplies many of them with the anhydrous ammonia on which the process is based. A number of other mills are studying the advantages of A.B.P.: shorter cooking time, wider use of woods, less maintenance, increased yields and, at lower cooking temperatures, better paper quality.

Let's talk it over . . .

If you're engaged in sulfite pulping, let a technical specialist from Allied tell you about the economies of Ammonium Bisulfite Pulping. Remember, no one has more experience with Ammonia than Allied.

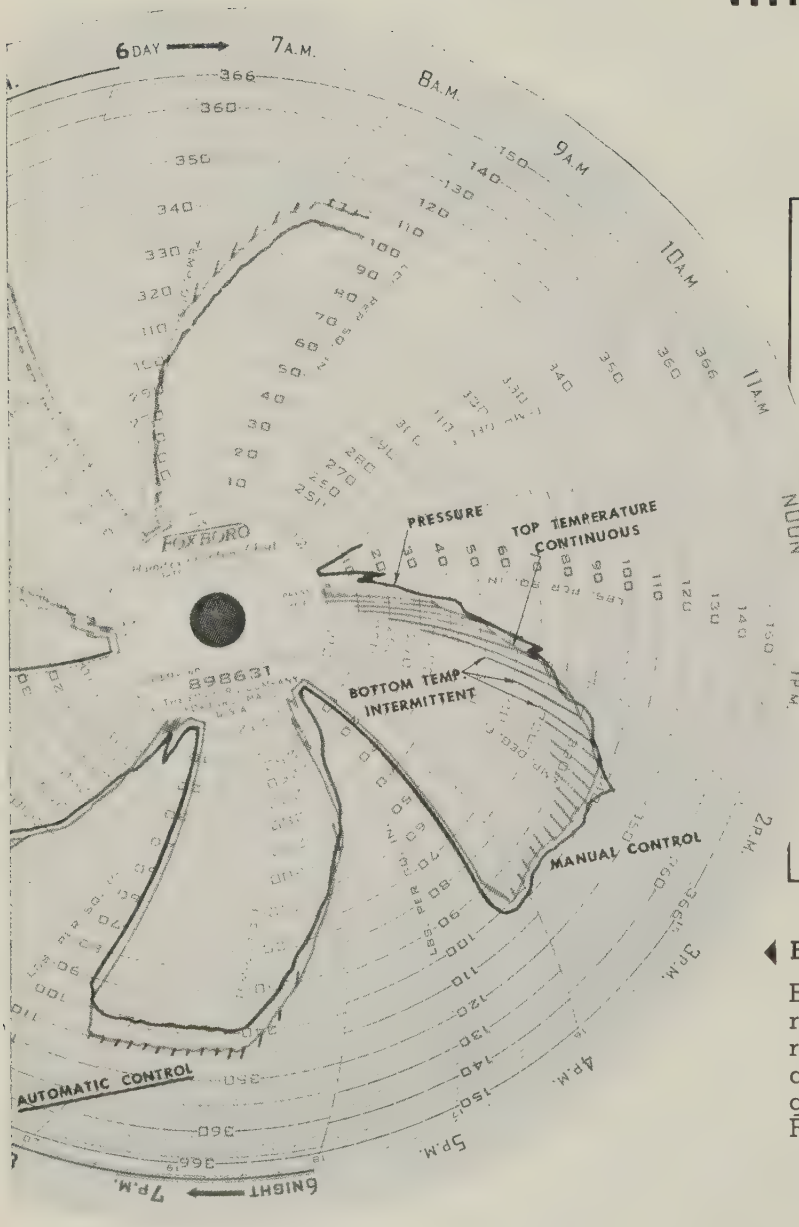
Allied Chemical

NITROGEN DIVISION

Dept. AA11-28-4, 40 Rector Street, New York 6, N. Y.

BIGGEST KRAFT ADVANCE

...New Foxboro system



Brings radically-improved results

- Uniform Permanganate
- Reduced Reject Variations
- Controlled Circulation
- No False Pressure
- Negligible Liquor Pull-over
- No Boiler Overload
- Significant Steam Savings
- Savings in Production Time

Easy-to-Read Record of Circulation

Exclusive, *top-and-bottom* temperature readings, as well as digester pressure, are recorded on this single Dynalog Recorder chart. Note how digester performance is greatly improved when operating under Foxboro Automatic Control.

FOXBORO
REG. U.S. PAT. OFF.

COOKING IN 20 YEARS!

introduces controlled digester circulation

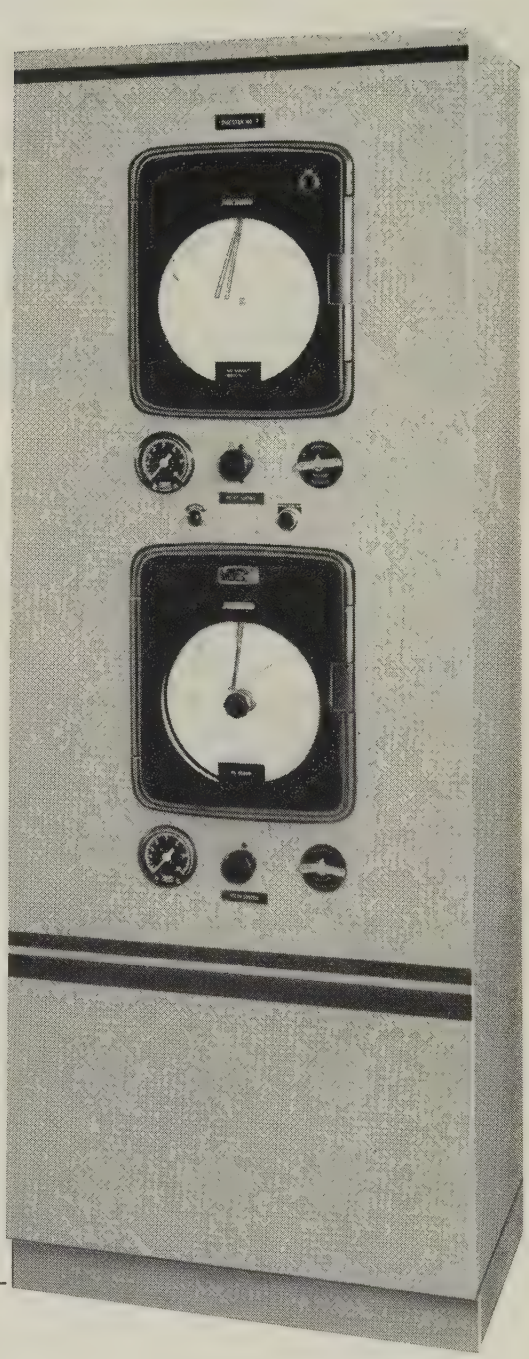
Featuring automatically inter-related controls for digester steaming and relief, this new Foxboro System for alkaline cooking brings important operating advantages never before possible!

Excellent circulation, with virtually no liquor pull-over, is achieved in part by automatically controlling the *flow* of relief (in reverse proportion to the steaming rate). This method of relief also maintains the required gas-off regardless of screen plugging. Blow-back, infrequently needed, is automatic.

Circulation is further improved and boiler overload is eliminated because steaming begins with flow control, with bumpless transfer to cam pressure control during the rise period.

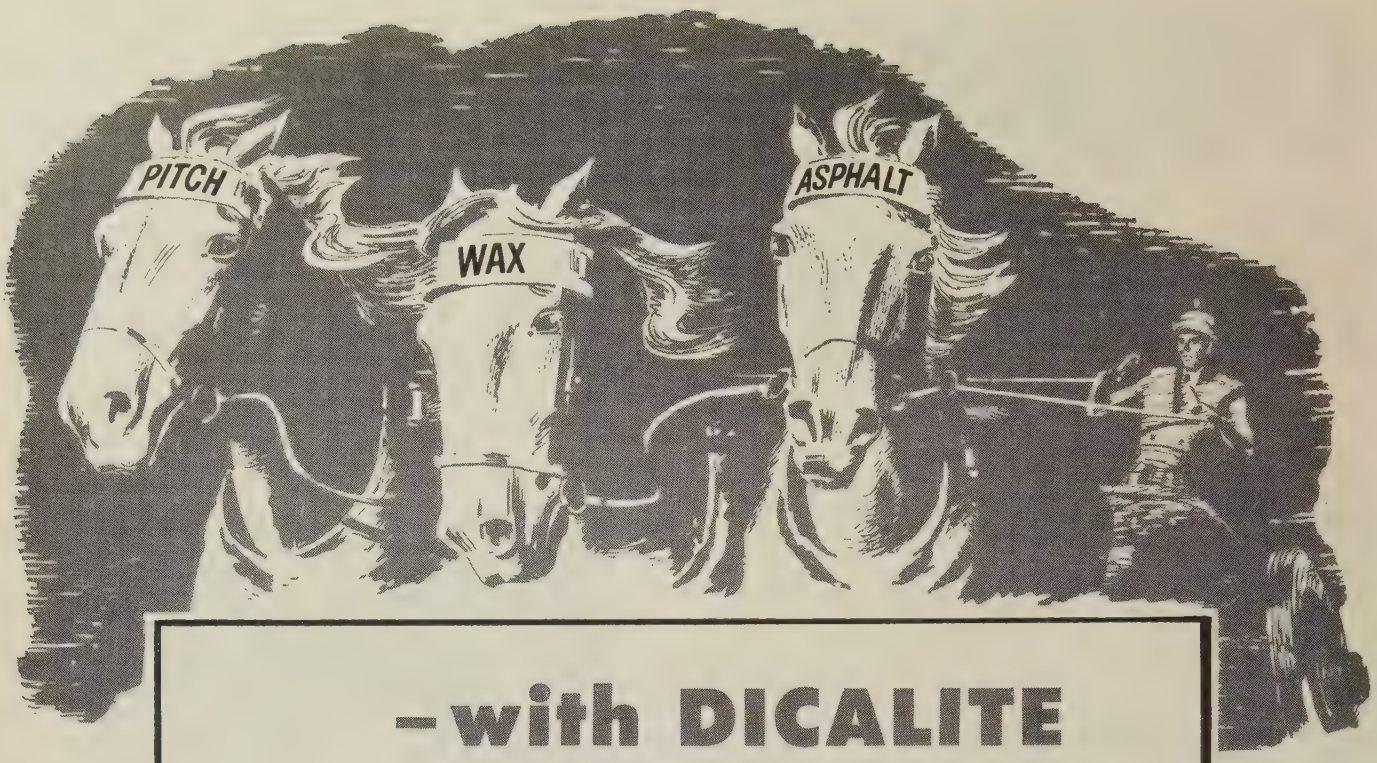
Operation is simpler than ever. To start a cooking cycle, the operator turns a single knob. The system completely and automatically controls the entire process until the end of cook.

For full details on this revolutionary new kraft digester control system, just call your nearby Foxboro Field Engineer, or write **The Foxboro Company, 782 Neponset Ave., Foxboro, Mass., U. S. A.**



Packaged Control System, pre-assembled and integrated in a compact control cabinet, ready to connect and start. Instruments, top to bottom, include: Dynalog Temperature and Pressure Recorder; Relief Flow-Indicating Controller; Cam Pressure Controller; Steam Flow Indicating Controller – plus auto/manual switches; manual controls for relief and steam valves; blow-back push-button and signal light.

AUTOMATIC DIGESTER CONTROL



–with DICALITE

it's easy to control all 3

It takes very little Dicalite Paperaid to tame these bad actors to the point where they'll give you little trouble. Dicalite doesn't remove them, naturally, but it does disperse them evenly, coating each tiny particle so they can't clump together. Through this one effect alone you reap two great advantages.

First, fewer breaks on the machine and greatly reduced collection on wires, felts and on dryer and calender rolls... less downtime, fewer cleanups, higher production. Second, an improved sheet since the tacky or oily particles are so controlled by the Dicalite that there is no noticeable spotting. In fact, furnish containing 10% waxed waste for sizing may be used for supercalendered white top liners with no indication of the wax being visible.

These, and the many other advantages of Dicalite in papermaking, are more fully discussed in Dicalite Technical Bulletin F-52. If you don't have a copy, why not send for it—now, while you think of it.

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

DICALITE DEPARTMENT, *Great Lakes Carbon Corporation, 612 So. Flower St., Los Angeles 17, Calif.*

There's an ATLANTIC wax for every dairy use

Take any assortment of waxed cartons for dairy use: cartons for milk, for butter, for ice cream, for cheese. Chances are that every one of them requires a different type of wax, with different physical characteristics.

That is why Atlantic offers a wax for every dairy use. This variety pays off . . . in improved appearance of your products, and in increased sales for your customers.

Deliveries can be made to suit your plant needs: in cartons, on pallets, in bulk haulers, or in tank cars. For complete information, write or wire The Atlantic Refining Company, 260 South Broad Street, Philadelphia 1, Pa., or any of the offices listed.

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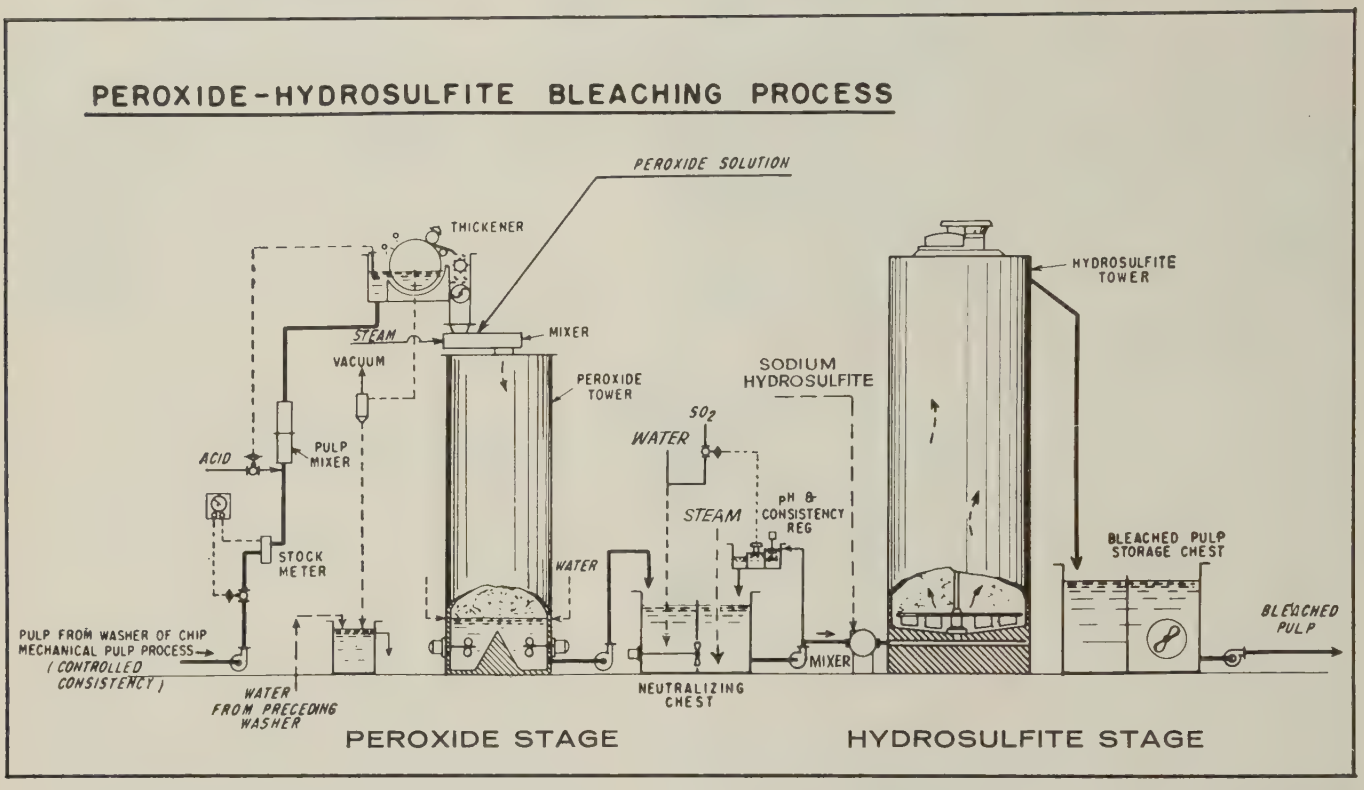
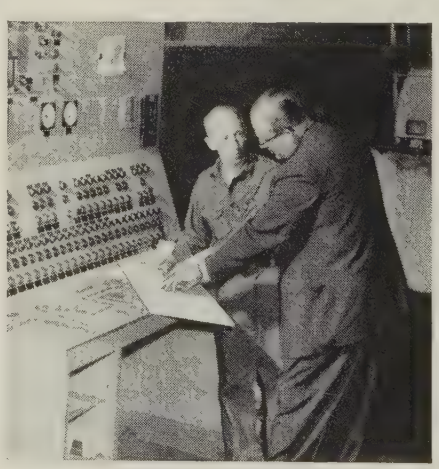
How Gould Paper Company peroxide bleaching method



TYPICAL TWO-STAGE BLEACHING SYSTEM starts with washing the pulp to remove chemicals used in initial chip treatment. Next, the slurry is acidified and thickened to 15% consistency. It is then bleached with peroxide and neutralized with sulfur dioxide.

The pulp is next diluted to 4% consistency and pumped to hydrosulfite tower. After bleaching and washing, it is then pumped continuously into the bleached pulp storage chest. After an additional refining step, the pulp is incorporated into the paper furnish.

CHECKING PULP SAMPLE during acidification step prior to peroxide bleaching. Acidification step was suggested by Du Pont technical men to insure that pulp would be bleached to maximum brightness.

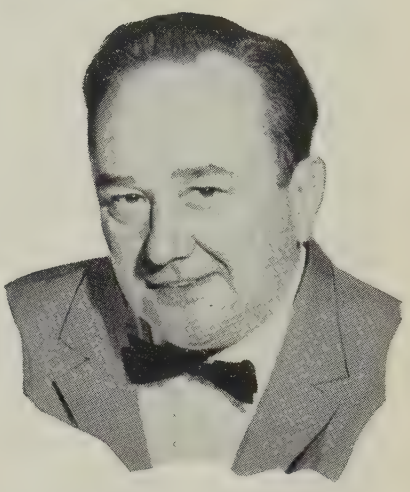


MASTER CONTROL PANEL keeps tab on entire bleaching process from beginning to end. Panel includes instruments that make trace recordings of data at critical points throughout bleaching process.

BLEACHED PULP is inspected by C. R. Lombard, Du Pont Technical Representative, after final washing before storage. Brightness is now 78-80 G.E. units . . . 35 points higher than unbleached pulp.

profits with the Du Pont for chip mechanical pulp

"Now we can use our hardwoods... get 78-80 G.E. pulp brightness... and we've upgraded our line"



— says R. W. Luethi, President and General Manager, Gould Paper Company, Lyons Falls, N.Y.

Gould Paper Company is the first to use the two-stage peroxide-hydrosulfite process for bleaching chip mechanical pulp. President R. W. Luethi reports: "We've been able to get into more profitable lines such as high-quality book papers since we adopted this process—and now we can use local hardwoods, such as birch, beech and maple, by the application of this cold soda process.

"Peroxide bleaching eliminates the yellowish cast our pulp had with our former hypochlorite system; it gives better whiteness and 78-80 G.E. brightness . . . *35 points* over unbleached pulp. Production is up, too, because of the better yield. In fact, plans are under way to double our present production by using this peroxide bleaching process."

DU PONT SERVICE CAN HELP YOU, TOO. Du Pont Technical Representatives worked closely with Gould's staff from initial planning to installation and operation of equipment. A special acidification step was developed by Du Pont to help Gould achieve pulp with maximum brightness. Practical technical men advised where Gould's existing equipment could profitably be used in the new system.

Du Pont know-how, gained through long and practical experience in the field of pulp bleaching with peroxides, made possible this modern bleaching process that Gould Paper Company is using so advantageously. Since Gould first went on stream, other mills have adopted this peroxide process for bleaching chip mechanical pulp and are enjoying its benefits.

SEND FOR FREE BOOKLET that describes in detail the Du Pont technique for bleaching chip mechanical pulp. Just write to the address below.

PEROXIDES **ALBONE®** hydrogen peroxide **SOLOZONE®** sodium peroxide

DU PONT
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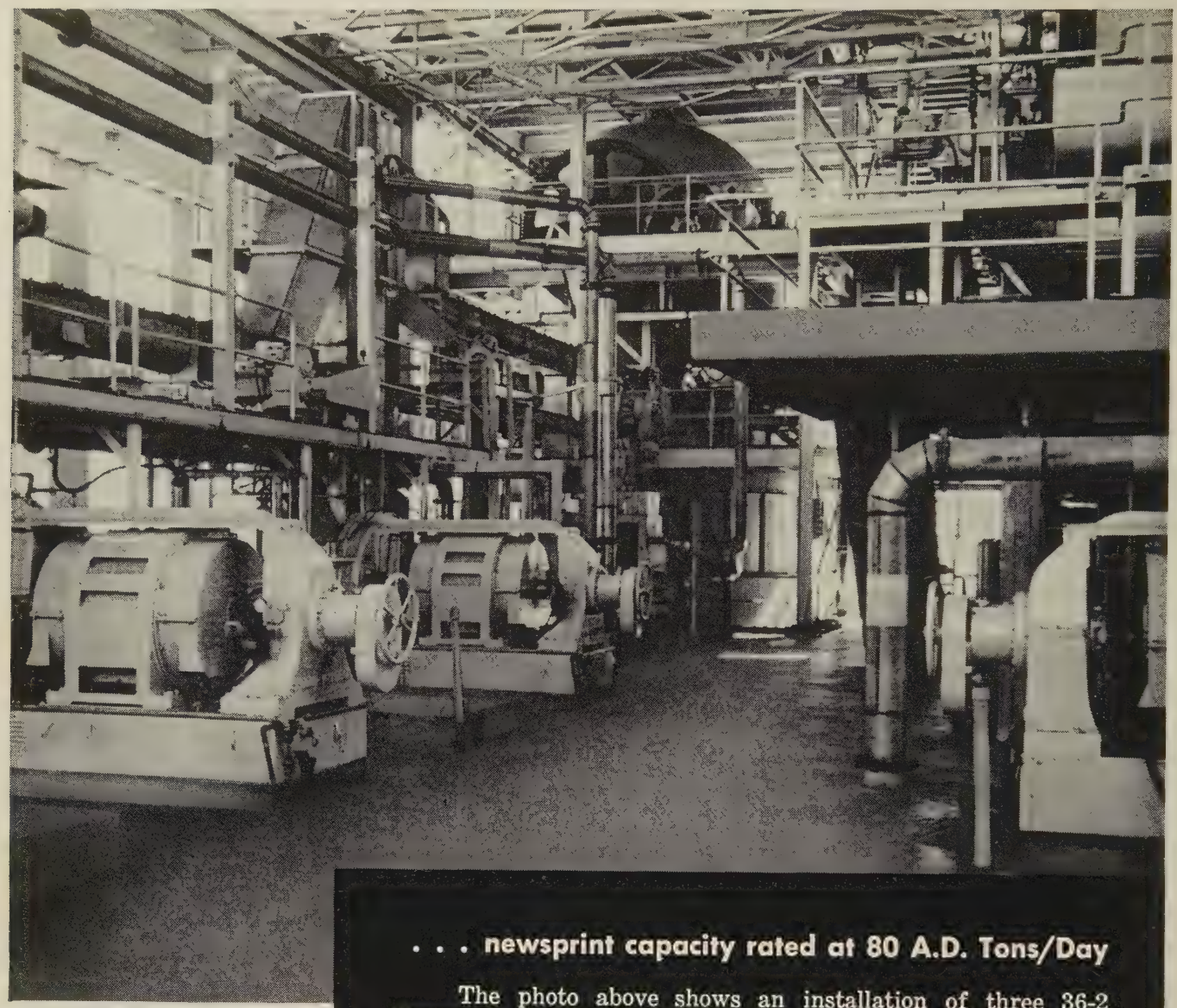
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

ELECTROCHEMICALS DEPARTMENT
Peroxygen Products Division

E. I. DU PONT DE NEMOURS & CO. (INC.)
Wilmington 98, Delaware

FIRST WITH PROCESSES AND SERVICES FOR PEROXIDE BLEACHING

Another Sprout-Waldron cold caustic installation . .



. . . newsprint capacity rated at 80 A.D. Tons/Day

The photo above shows an installation of three 36-2 "Sprouts" producing 40 A.D. tons/day of cold caustic pulp at the modern Australian Newsprint mill. Three additional precision-built, Sprout-Waldron Refiners have since been installed to bring the capacity up to 80 A.D. tons/day.

The use of 20% cold caustic has meant lowered operating costs, increased machine speeds, reduced furnish costs, and newsprint strength equal to the world's best. Sprout-Waldron's experience with cold caustic includes successful commercial installations producing a variety of pulps. Why not put this experience to work for you. Our representative will be glad to review the possibilities at your convenience.

REPRINTS AVAILABLE

The full story of this Australian Newsprint installation is being published by the Australian Pulp and Paper Industry Technical Association (A. P. P. I. T. A.). We intend to reprint it in Better Fibers. A note on your letterhead will reserve your copy.

SP/111

SINCE 1866

SPROUT, WALDRON & CO., INC. MUNCY, PENNA.

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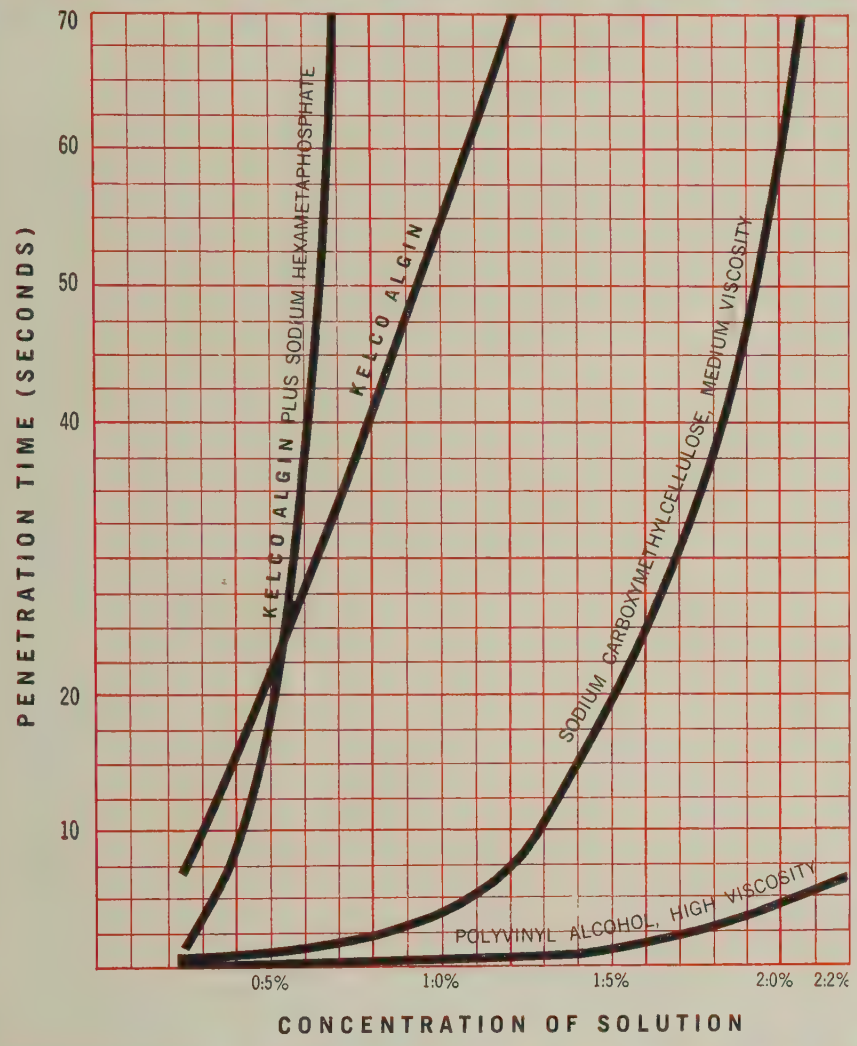
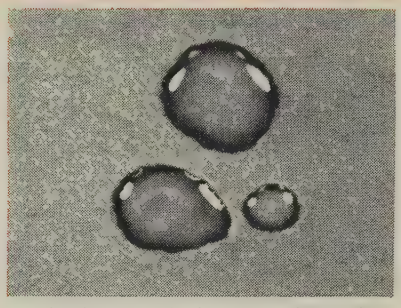
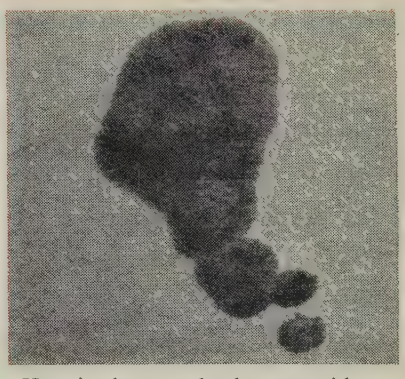
Remarkable! The way Kelco Algins give greater

PENETRATION





This photograph shows a 1% solution of Kelco Algin twenty minutes after being puddled on blotter. Note how algin controls penetration and retains solution on surface of blotter. This test illustrates the outstanding ability of algin to control penetration. With it you can get the exact degree of hold-out desired for sizings, coatings, adhesives, inks, etc.



Here is photograph of water, without algin, on same piece of blotter taken seconds after water was placed on blotter. Note how water passed immediately into blotter compared to controlled penetration of algin solution.

CONTROL

This graph and blotter test illustrate and prove that KELCO ALGIN products are among the most efficient materials available for controlling penetration. By using proper proportions of a product such as KELGIN, KELGIN LV, KELGIN XL or KELSIZE, manufacturers of paper products can regulate the amount of penetration of size formulations, clay and wax coatings, printing inks, adhesives, etc. Of course, having your formulation where you want it, without excessive and unnecessary penetration, saves you money.

MAKE YOUR OWN TEST: Samples, information and technical service, yours on request without obligation.

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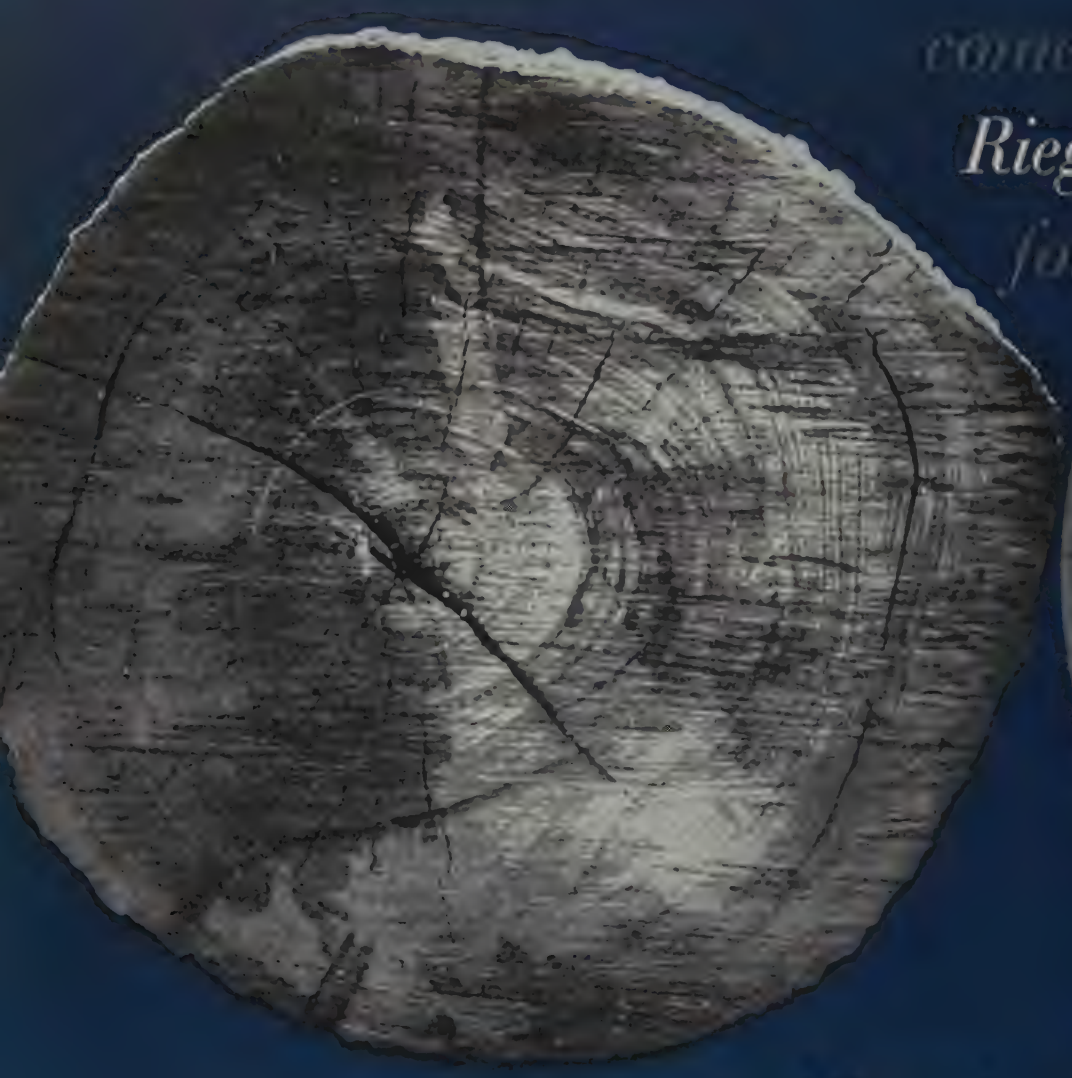
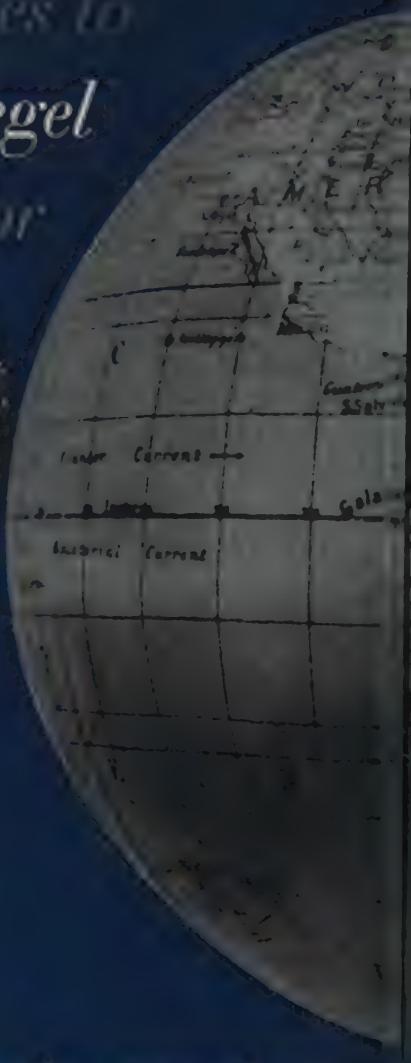
The world comes to Riegel for

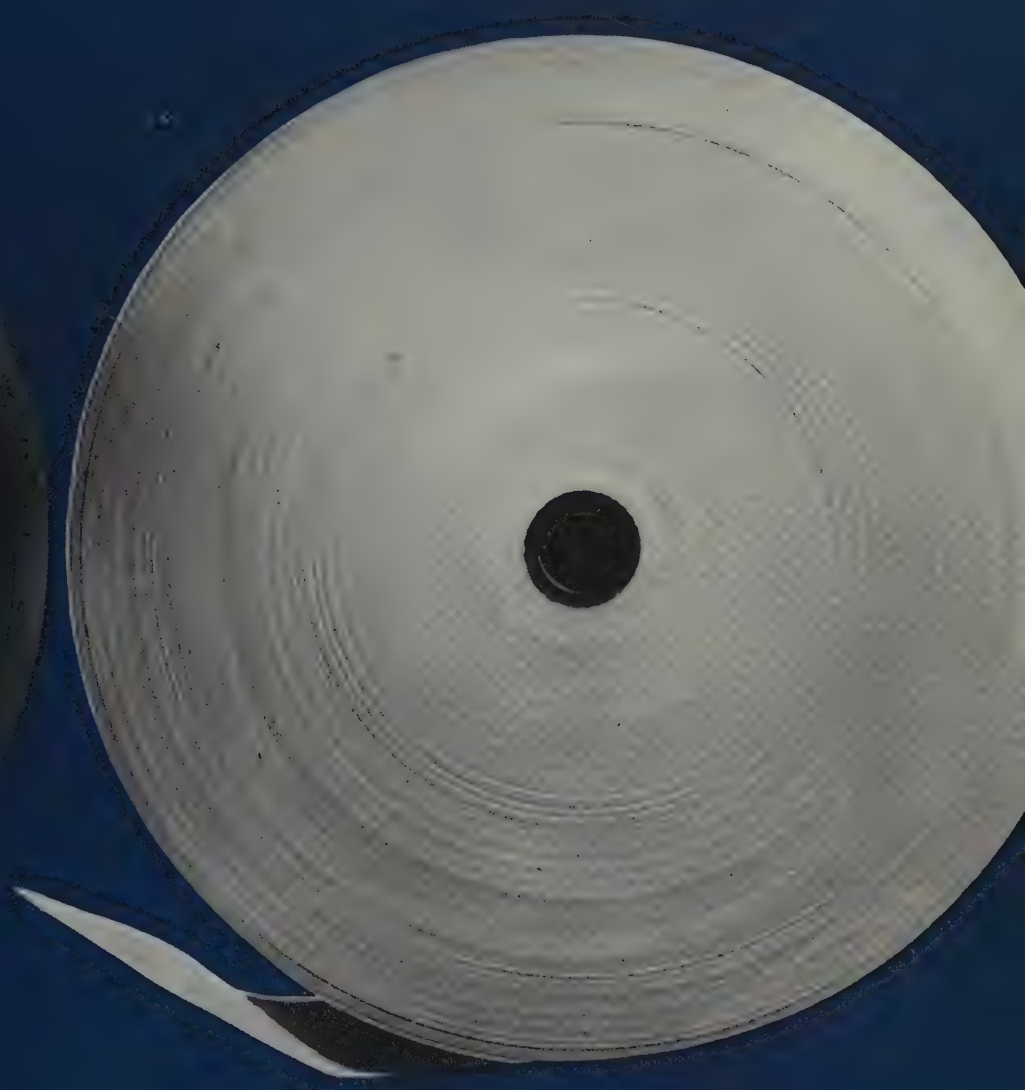




Albacel & Astracel

Chlorine Dioxide Bleached Softwood Sulphate *Chlorine Dioxide Bleached*

balanced paper-grade pulps created by papermakers for papermakers



ardwood Sulphate

Throughout the free world, papermakers use and like Riegel's Albacel and Astracel, the paper-grade pulps that provide the right balance of all important qualities for brightness, cleanliness, strength, formability and proper beating characteristics.

Riegel Paper Corporation

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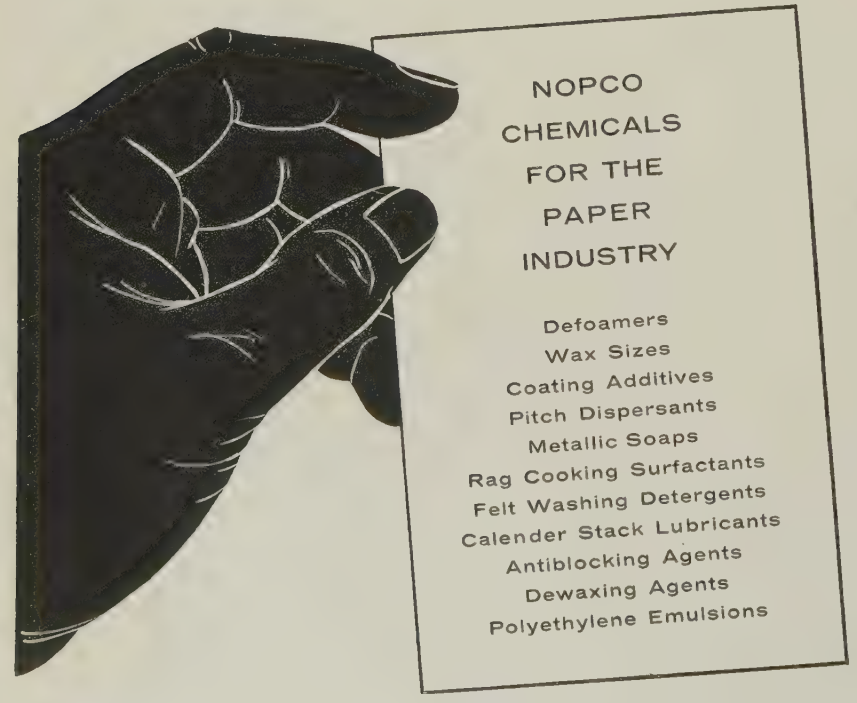
From the Nopco® line of paper chemicals come the agents that make good paper better.

From the Nopco research laboratories come the know-how and techniques amassed in more than 50 years of service to the paper industry—knowledge and facilities that are always available to you to help meet your special requirements.

Write today for complete information about Nopco paper chemicals, plus Nopco research facilities, available to you. You will find it profitable.



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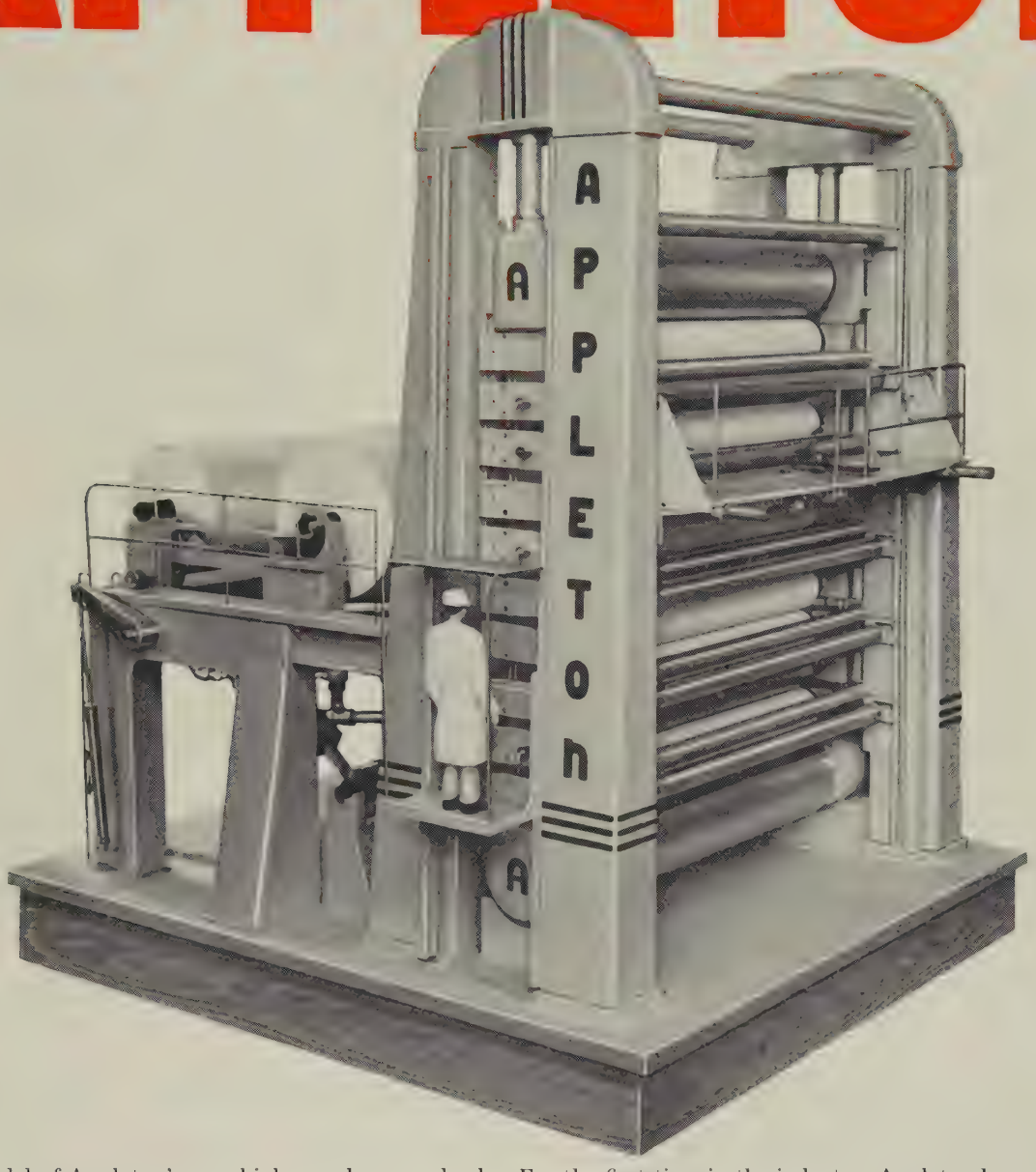
APPLETON



This is a model of Appleton's new high-speed supercalender. For the first time in the industry, Appleton has combined the advantages of a 4-column supercalender with the roll removal features of an open-face stack. At the same time, this revolutionary Appleton design eliminates many of the difficulties inherent in an open-face stack — couching of rolls, necessity of dismantling auxiliary rolls to change filled rolls. NEW APPLETON HIGH-SPEED SUPERCALENDER FEATURES: In addition to the many advanced features standard on all Appleton stacks, this new high-speed supercalender has: **All parts easily accessible by lifts and elevators . . . Filled rolls removed from back of stack onto full length elevators . . . Unwind with semi-automatic parent roll handling and empty spool transfer to windup . . . Windup with semi-automatic spool handling and wound roll transfer . . . Calender roll housings maintained in vertical alignment by four columns . . . Housings equipped with retractable ball-bearing casters riding in ways . . .** Perhaps this new Appleton supercalender can prove profitable to your operation. We invite you to write for complete technical data. **ON DISPLAY IN THE APPLETON BOOTH AT THE TAPPI MEETING.**

APPLETON MACHINE COMPANY

APPLETON, WISCONSIN

R/M CONVEYOR BELTS OUTLAST THEM ALL

on tough Paper Mill installations

Homoflex Log Conveyor Belt absorbs the shock of logs rolling from debarker at large Virginia paper mill.

Handling chips or newly debarked logs—R/M conveyor belts are engineered to stand up where ordinary conveyor belts tear, puncture or fail due to fastener pull out. Ray-Man Conveyor Belt, for example, trains naturally, troughs easily —to handle *fuller*, *heavier* loads even where small pulleys are used. Compensated, balanced construction prolongs belt life. Ray-Man requires no breaker strip, offers exceptional fastener and splice holding ability under extreme operating conditions.

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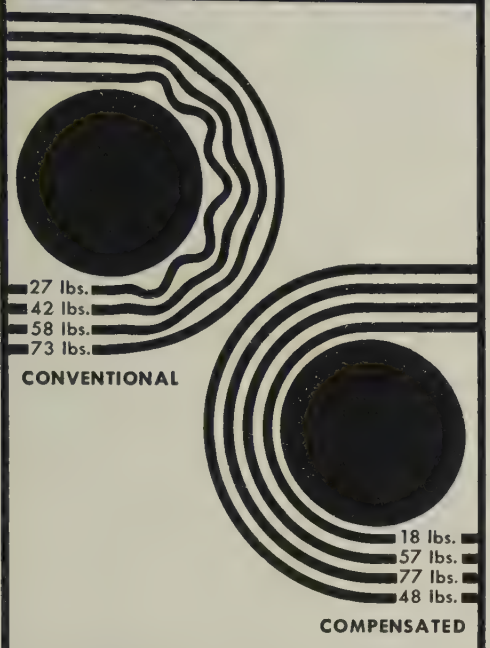

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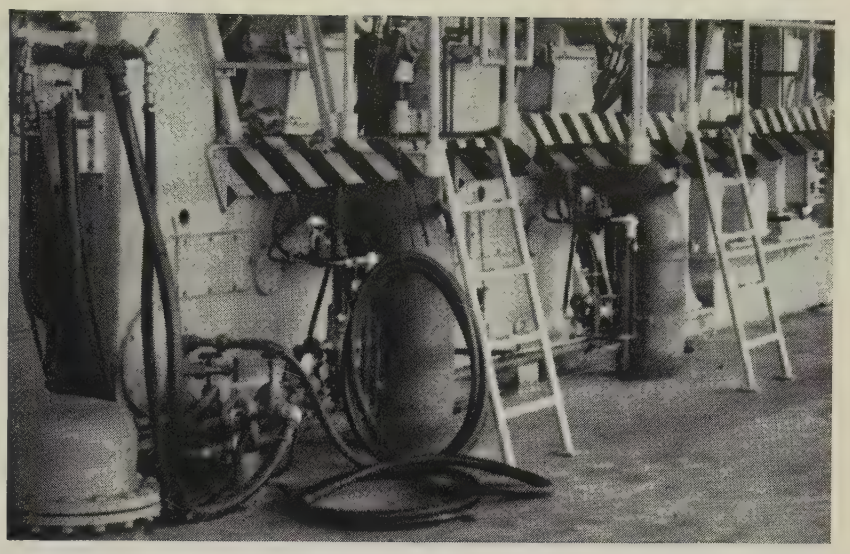

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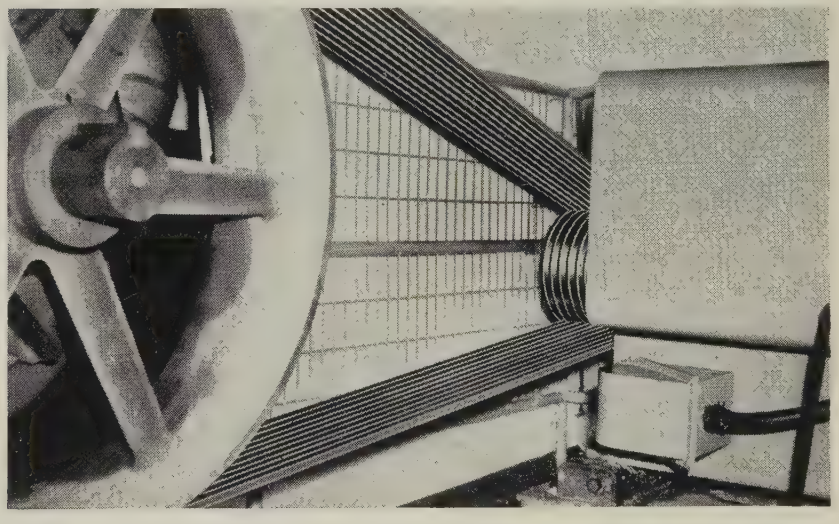

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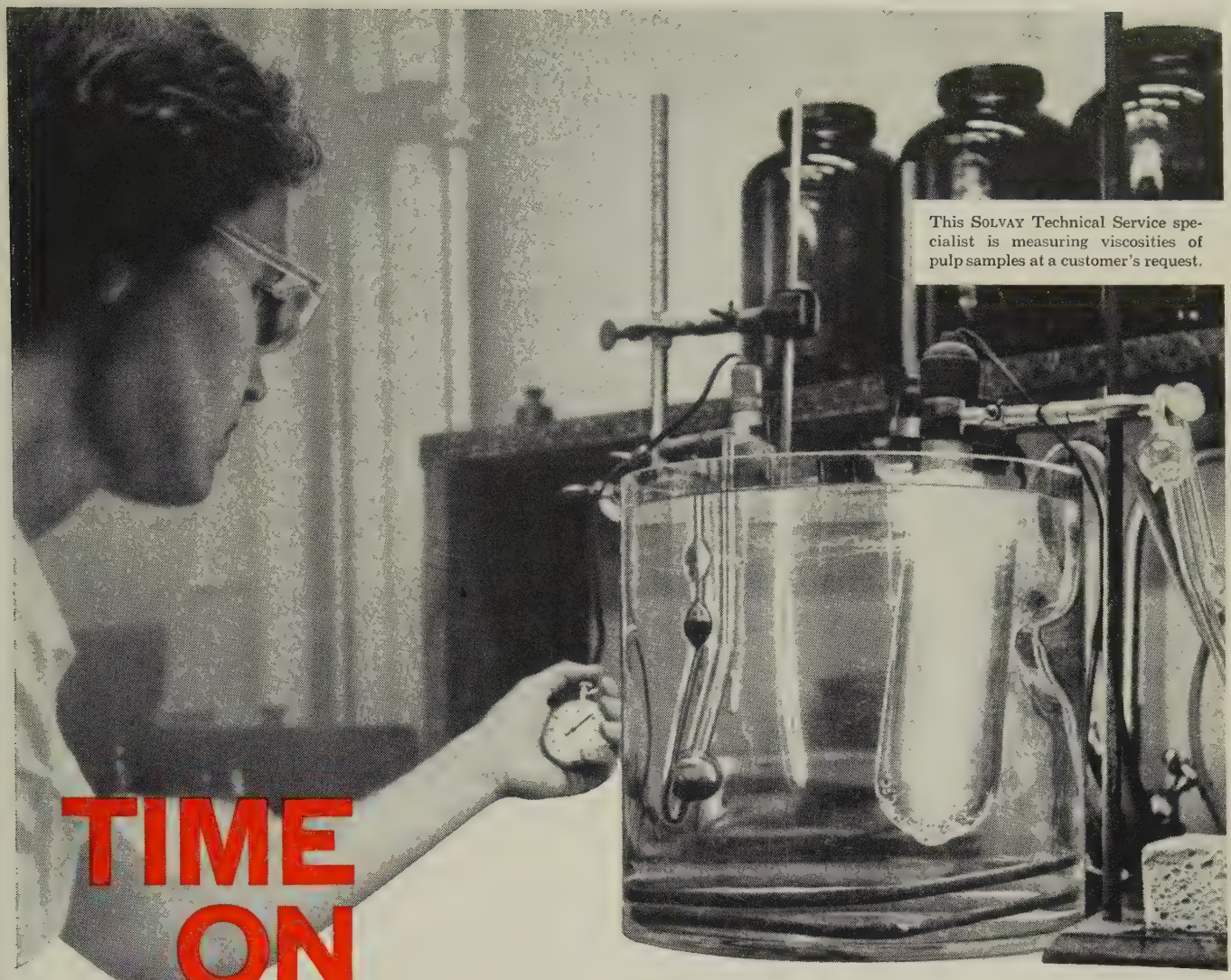

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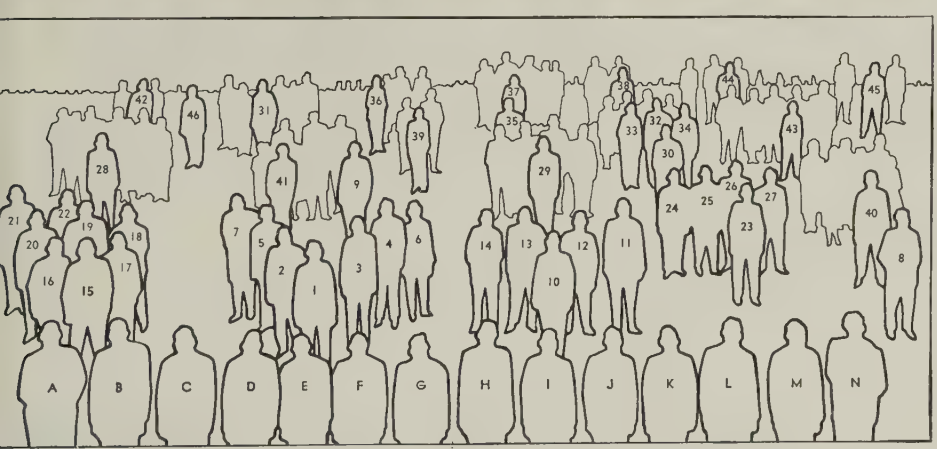

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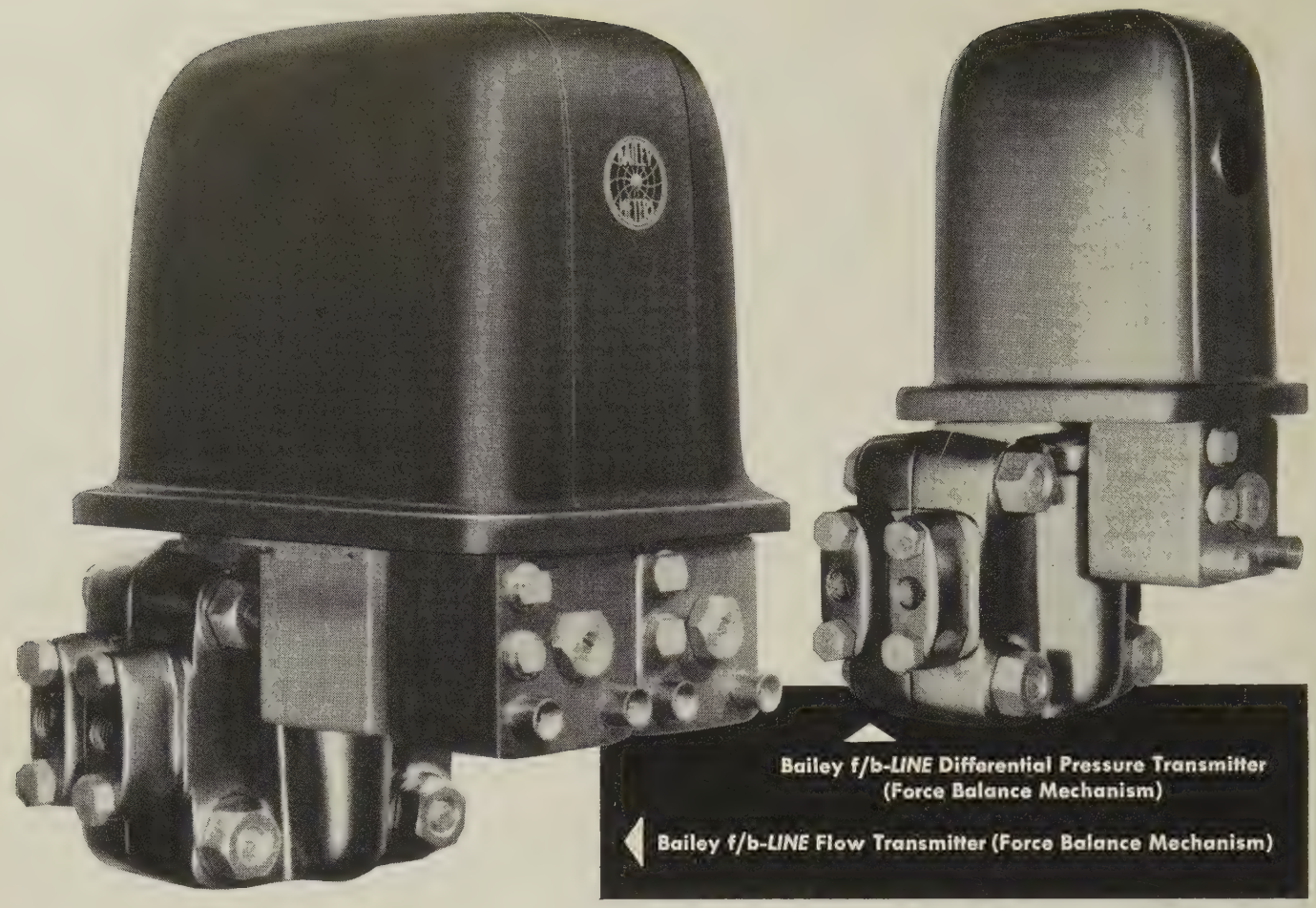
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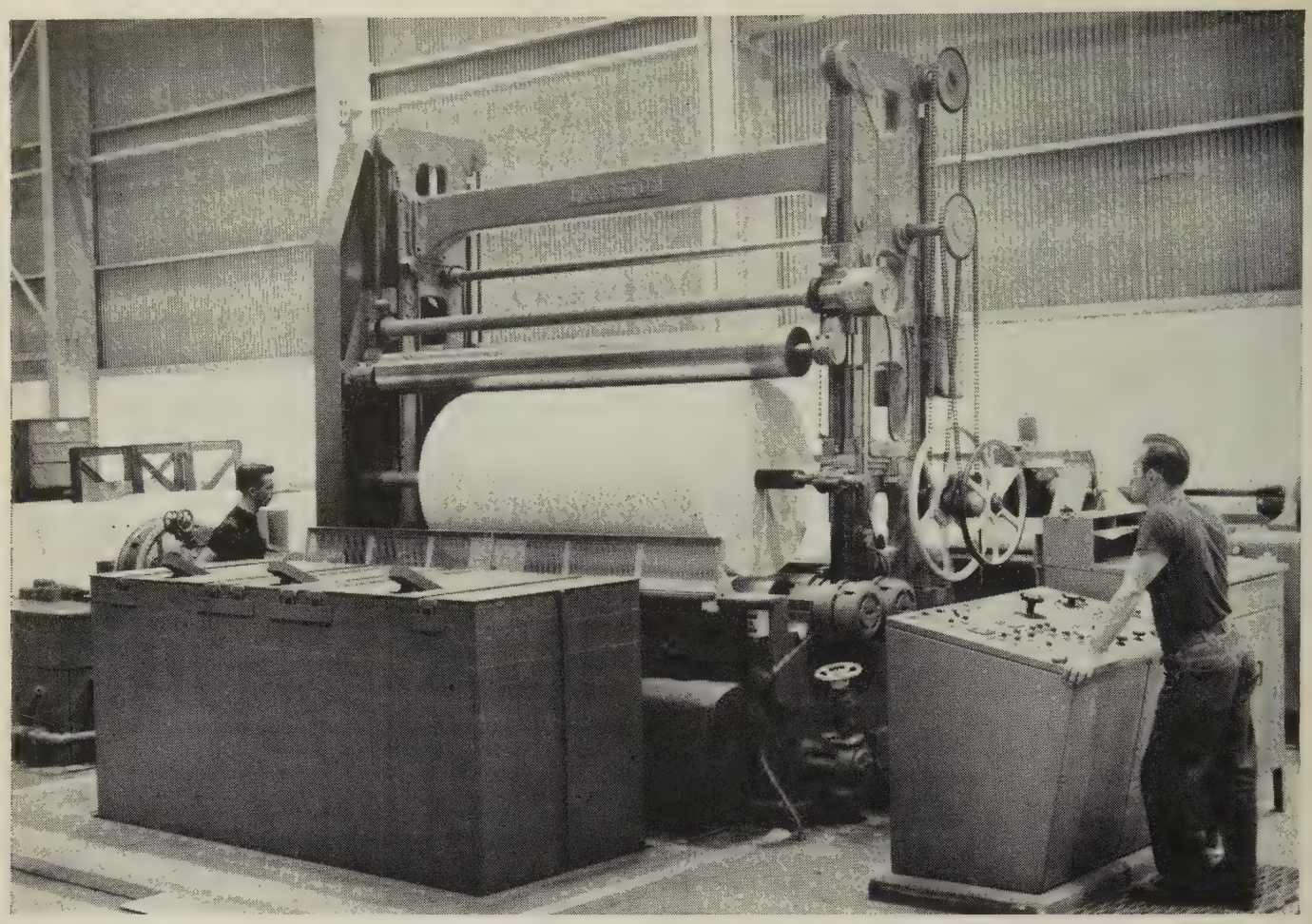

One of the two 104-in. Langston Slitters and Winders in the Glatfelter mill completing rewind. Roll drop table in foreground is up, ready to receive roll when ejected by the winder, and chocks are in raised position to stop the roll. Note console incorporating all major indicators and controls.

Langston Slitters and Winders turn out tight, even rolls at Glatfelter Mill

Two 104-in. Langston Slitters and Winders have been working in the new mill of P. H. Glatfelter Co., Spring Grove, Pa., for more than a year. They have proved themselves in round the clock production on grades from fine papers to book.

One of the most important features, according to the company, is the constant tension unwind control on the Langston Shaftless Roll Stand, which keeps the tension constant throughout the winding operation. Perfect rolls can be turned out from 9 to 100-lb. stock in roll widths from 7½ to 104 in.

The equipment can be quickly loaded and lined up on the back stand and is designed for easy threadup and gang slitter setting. Hydraulic roll ejectors move the finished rolls quickly from the winding position to the roll drop. Other features include shearcut slitters to eliminate dust; many interlocked controls for extra safety; automatic edge guide control to allow precision trim rewinding of narrow and salvage rolls.

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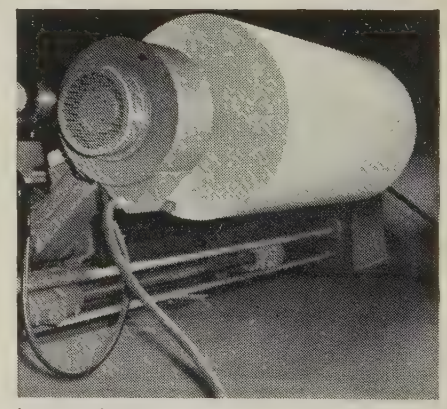
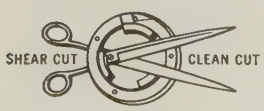


Langston Shaftless Unwind Stand eliminates back-breaking, time-consuming task of hoisting heavy shafts into place. Hydraulically operated arms reach out, pick up the roll, and raise it into running position—a 1-man, pushbutton operation.



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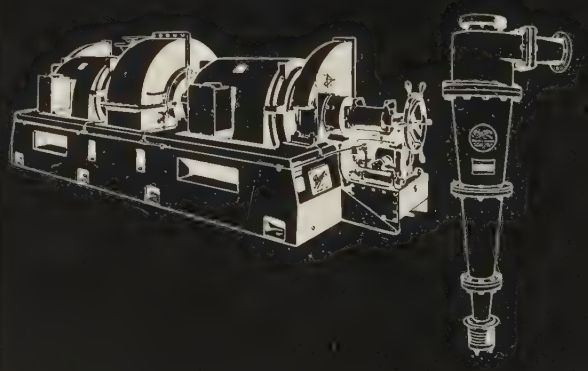

A Correlation for the Hercules, Hagan, and Brookfield Viscometers for a Newtonian Fluid*

R. C. CHASE

Because the rates of shear per unit of scale and the torque developed are not the same for the Hercules, Hagan, and Brookfield viscometers it has been difficult for a worker using one instrument to exchange data with a worker using another. An attempt has been made to correlate the instruments using a Newtonian fluid of known viscosity. Since the Brookfield does not have an annular space on the same order as the Hercules and Hagan a rate of shear has been developed using an annular space in the same range as the Hercules and Hagan.

THE most commonly accepted method for studying the rheological properties of high solids suspensions has been with the use of viscometers of two general types; the rotational or Couette type which produces a continuous curve of torque versus rate of shear at varying shear rates, and the single point instrument which measures the torque at a fixed rate of shear. Since both types of instrument are in use in the paper coating industry it has been deemed advisable to determine what correlation if any could be made of the results obtained on the various instruments.

Through the courtesy of the Brookfield Engineering Laboratories an eight-speed Brookfield synchroelectric viscometer was made available for use in these tests. In addition, the Hagan Corp. made available a Hagan high shear viscometer. A Hercules high shear viscometer was already in use on the project.

Before attempting to analyze or interpret the rheological data for high solid non-Newtonian paper coating colors a correlation was developed for these viscometers using a Newtonian liquid. The liquid chosen for use was a Dow Corning silicone fluid of the 200 series reported to have a kinematic viscosity of 1000 centistokes.

PROCEDURE

Brookfield Viscometer

The viscosity of the Dow Corning 200 fluid was measured by suspending each of the seven spindles supplied with the instrument in the fluid contained in an 800-ml. beaker without the guard legs attached. The temperature of the tests was held constant at 77 ± 2°F.

Two different sets of observation were made: one with a constant number of revolutions of the spindle before changing to the next spindle speed and one with a constant time interval before changing the spindle speed. Using both of these methods observations were made of the scale reading while continually increasing the revolutions per minute to a maximum and while decreasing from maximum to minimum revolutions per minute. The number of revolutions per minute chosen for the tests conducted at constant revolutions per minute interval was determined by trial and the value of 10 revolutions before reading and shifting to the next scale was one which was not so small as to prevent accurate counting at 100 r.p.m. The time interval for the tests conducted at constant time was selected in a similar fashion and the value adopted was 20 sec.

All tests were conducted with the instrument leveled and the spindle immersed to the mark designated by the manufacturer. Observations were made starting at the lowest value of 0.5 r.p.m., continuing in steps through 1, 2.5, 5, 10, 20, 50, and 100 r.p.m. and then reversing the process to the minimum speed. Values for the viscosity obtained with each spindle at each revolution per minute were obtained from the conversion chart supplied with the instrument and are shown in Tables I and II.

In order to correlate these data with the data for the Hercules and Hagan viscometers where viscosity is plotted against rate of shear a theoretical maximum rate of shear for each spindle of the Brookfield was calculated by assuming that the shear was taking place in an annulus of the same dimensions as the annulus of the Hercules and Hagan viscometers. The annulus of the Hercules is constant regardless of the bob used and has a value of 0.0813 cm. The clearance between the bob and the cup wall in the Hagan varies with the bob used and has a value of 0.161 cm. for the low shear bob, and 0.041 cm. for the high shear bob. In order that all clearances would be in the same range a value was chosen of 0.086 cm. for the hypothetical annulus using the Brookfield. Using the method of Smith and Applegate (*1*) the average rate of shear can be

Table I. Viscosity in Centipoises at Constant Revolutions per Minute Interval

(1000 centistoke Dow Corning 200 fluid)

	Spindle no.						
r.p.m.	*1*	*2*	*3*	*4*	*5*	*6*	*7*
0.5	1180	1120	1200	1600	1600	4000	8000
1.0	1150	1000	1000	1000	1200	2000	4000
2.5	1350	1005	960	960	1120	1600	1600
5.0	1355	985	940	920	1040	1200	2000
10.0	N.R.	990	940	920	1040	1100	1600
20.0	N.R.	996	945	900	1020	1100	1400
50.0	N.R.	N.R.	950	916	1000	1040	1200
100.0	N.R.	N.R.	954	914	1010	1040	1040
50.0	N.R.	N.R.	954	914	1000	1040	960
20.0	N.R.	996	950	900	1020	1100	1000
10.0	N.R.	990	950	920	1040	1100	1600
5.0	1355	985	940	920	1115	1400	1600
2.5	1360	1020	960	960	1120	1600	1600
1.0	1340	1000	1000	1000	1600	2500	4000
0.5	1340	1120	1000	1200	1600	2000	8000

(N. R. — No reading)

R. C. CHASE, Instructor, Department of Chemical Engineering, University of Maine, Orono, Me.

* This project was supervised by the Coating Committee and was financed by TAPPI Research Grant No. 100.

Table II. Brookfield Viscometer Viscosity in Centipoises at Constant Time Interval
(1000 centistoke Dow Corning 200 fluid)

r.p.m.	Spindle no. 1	2	3	4	5	6	7
0.5	1040	1040	1000	1600	1600	2000	8000
1.0	1120	1000	1000	1000	1600	2500	4000
2.5	1120	993	961	960	1118	800	1600
5.0	1170	984	940	960	1118	1000	1600
10.0	N.R.	984	930	940	1080	1200	1600
20.0	N.R.	994	935	930	1040	1000	1000
50.0	N.R.	N.R.	945	936	1023	1040	1200
100.0	N.R.	N.R.	948	935	1029	1040	1200
50.0	N.R.	N.R.	945	940	1016	1040	1119
20.0	N.R.	994	940	940	1040	1050	1200
10.0	N.R.	989	940	940	1080	1200	1600
5.0	1172	991	940	960	1118	1200	2400
2.5	1146	993	961	960	1118	1600	1600
1.0	1120	1000	1000	1000	1600	2500	4000
0.5	1120	960	1200	1600	1600	4000	8000

approximated by dividing the linear velocity of the rotating bob of the instrument by the width of the annular space. (The reader is urged to note that a typographical error appears in this article (*1*) between equations (5) and (6). The instrument constant should read $(1/R_o^2 - 1/R_c^2)/4h$ and does so in the following equations.) The rate of shear developed by the Brookfield becomes,

$$\frac{dv}{dr} = \frac{(\text{r.p.m.})\,(2\pi\, r_s)}{(60 \text{ sec./min.})\,(\text{annular clearance})} \qquad (1)$$

where $\frac{dv}{dr}$ = rate of shear in reciprocal seconds

r_s = radius of spindle in centimeters

annular clearance = 0.086 cm.

this becomes

$$\frac{dv}{dr} = (1.217)(\text{r.p.m.})(r_s) \qquad (2)$$

The maximum rate of shear thus calculated becomes

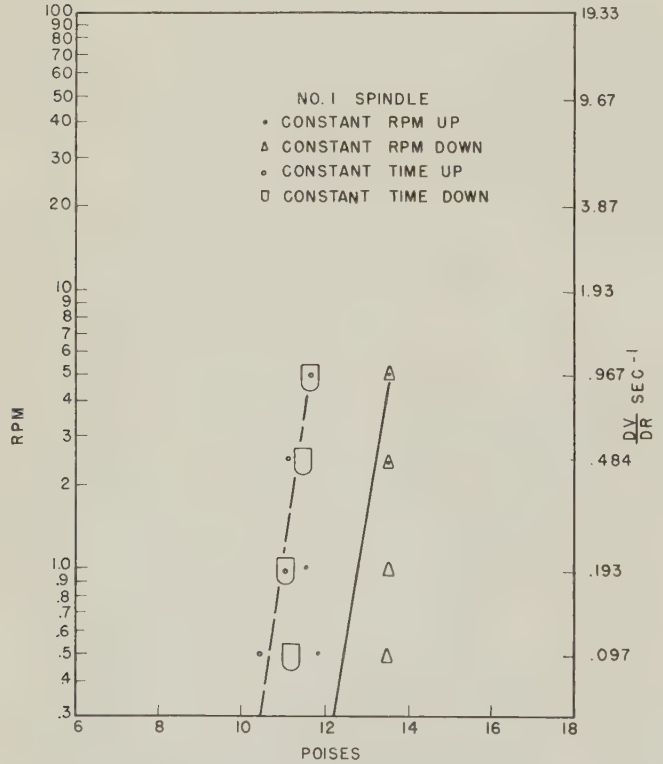

Fig. 1. Variation in apparent viscosity with log of revolutions per minute; Brookfield viscometer

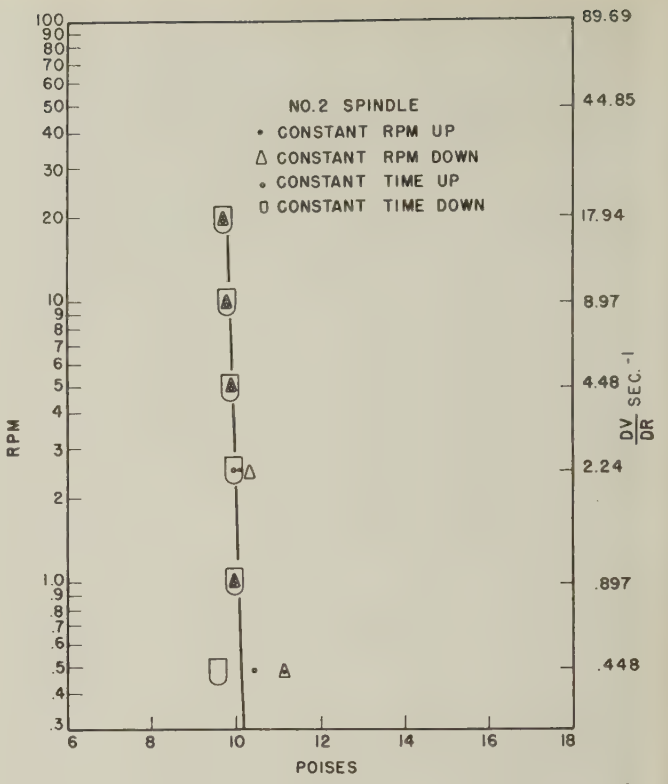

Fig. 2. Variation in apparent viscosity with log of revolutions per minute; Brookfield viscometer

338 reciprocal sec. Another method of calculating the maximum rate of shear dv/dr at the bob wall for a concentric cylinder viscometer where the outer cylinder has an infinite radius has been developed by Krieger and Maron (*2*). A somewhat similar method has been applied to the Brookfield viscometer by Alnes, Boucher, and Pigford (*3*).

While the method used in this work may be subject to mathematical criticism it gives a value for the rate of shear which is quite accurate for highly viscous materials with a yield stress where most of the shear occurs at the bob wall. Alnes, Boucher, and Pigford obtained a maximum rate of shear of approximately 80 reciprocal sec. as compared to 338 reciprocal sec. obtained by the method outlined above. They do not state the dimensions of the spindles supplied with the instrument used in their work thus it is impossible to compare results directly.

Hagan Viscometer

In order to use the Hagan viscometer it is first necessary to calculate the torque scale constant for each of the three ranges of the instrument. By using a set of check weights provided with the instrument a graph of check weight in ounces versus per cent of full scale deflection is plotted for each of the three ranges. The check weight value in ounces at 50% of full scale is then inserted in the following equation:

$$T_{sk} = \frac{(W)(L)(70416)}{50} \qquad (3)$$

where

T_{sk} = torque scale constant
W = check weight value in ounces at 50% of scale
L = torque arm radius in inches
70416 = constant to convert inch-ounces to dyne-centimeters
50 = constant to determine T_{sk} at 1% of scale

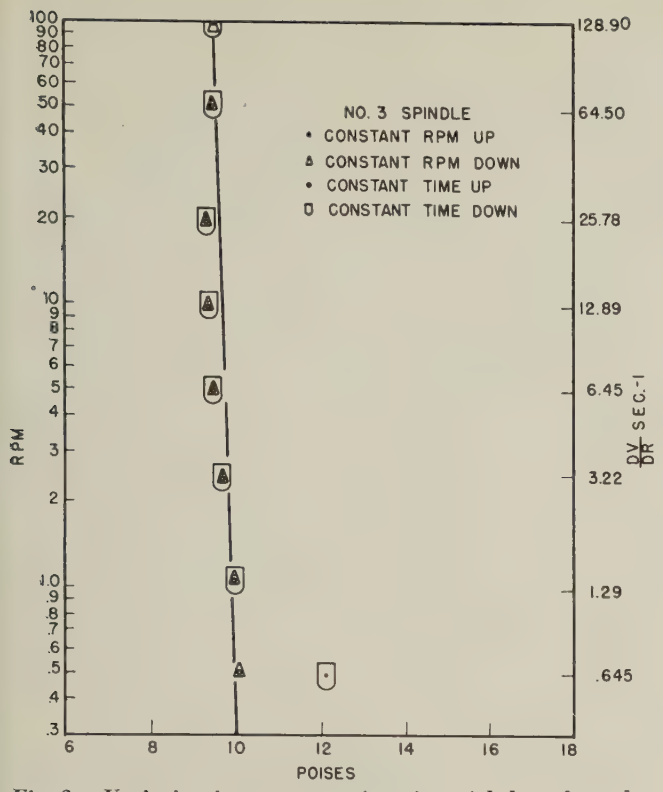

Fig. 3. Variation in apparent viscosity with log of revolutions per minute; Brookfield viscometer

The length of the torque arm supplied with the instrument used in this study was 1.97 in. The following values for the torque scale constant, T_{sk} were obtained:

Low range = 4850 dyne-cm./1% of scale
Medium range = 12,680 dyne-cm./1% of scale
High range = 49,000 dyne-cm./1% of scale

The total torque can be obtained at any point on the graph by multiplying the torque scale constant for the appropriate instrument range by the per cent of full scale deflection.

In order to calculate Newtonian viscosity an instrument constant, S, must be developed according to the method of Green (*7*), following Reiner (*5, 6*). (The reader is urged to note that a typographical error appears on page 37 of the first edition of (*7*). Equation (32) should read $T = (F)\ (2\pi r)\ (r)\ (h)$. The omitted term (h) is included in following equations.)

$$S = \frac{(1/R_b^2) - (1/R_c^2)}{4\pi h_b} \qquad (4)$$

where

S = instrument constant
R_b = radius of the bob in centimeters
R_c = radius of the cup in centimeters
h_b = height of the bob in centimeters

In the Hagan viscometer the cup radius is a constant and the radius and the heights of the bobs vary. The instrument constant S, as well as the dimensions of the bobs appear in Table III.

Table III. Instrument Constants for Hagan Viscometer

	Low shear bob	*Medium shear bob*	*High shear bob*
Cup radius, cm.	1.906	1.906	1.906
Bob radius, cm.	1.745	1.820	1.865
Bob height, cm.	2.500	2.000	2.000
S	0.00169	0.00105	0.000485
$\frac{dv}{dr}$ (scale reading)	(55.7)	(108.0)	(227.5)

The rate of shear as listed in Table III is calculated from a plot of bob speed in revolutions per minute versus chart scale deflection in order to obtain the chart scale constant W_{sk} and the equation:

$$\frac{dv}{dr} = \frac{(W_{sk})(\text{scale reading})}{2\pi h_b S r^2} \qquad (5)$$

where

$\frac{dv}{dr}$ = rate of shear in reciprocal seconds at radius r
W_{sk} = chart scale constant = 4.93 radians per 1% of scale
h_b = height of bob in centimeters
S = instrument constant [see eq. (4)]
r = radius in centimeters at which dv/dr is calculated

Green (*7*) states that when the difference between the radius of the cup and the radius of the bob is small the average radius $(R_c + R_b)/2$ can be used for r in equation (5) and will give a close approximation to the rate of shear. Equation 5 then becomes:

$$\frac{dv}{dr} = \frac{(W_{sk})(\text{scale reading})}{2\pi h_b S(R_c + R_b)^2/2} \qquad (6)$$

It is then possible to calculate Newtonian viscosity from the following formula:

$$u = \frac{(T_{sr})(T_{sk})(S)}{(W_{sr})(W_{sk})} \qquad (7)$$

where

u = viscosity in poises
T_{sr} = torque scale reading in per cent of full scale
T_{sk} = torque scale constant
S = instrument constant
W_{sr} = chart angular velocity in per cent of full scale
W_{sk} = chart scale constant

The Newtonian viscosity as determined by each bob for each of three instrument ranges is given in Table IV.

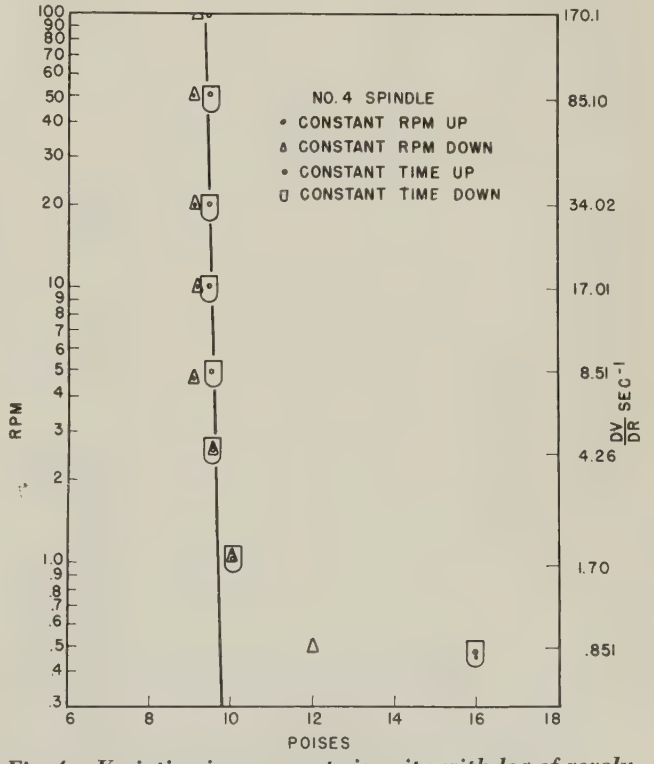

Fig. 4. Variation in apparent viscosity with log of revolutions per minute; Brookfield viscometer

Table IV. Hagan Viscometer Viscosity in Poises
(1000 centistoke Dow Corning 200 fluid)

Low bob		Medium bob		High bob	
$\frac{dv}{dr}$	u	$\frac{dv}{dr}$	u	$\frac{dv}{dr}$	u
		Low Range			
183	5.24	313	3.70	455	2.48
285	6.42	475	4.87	659	3.02
412	7.01	604	5.56	819	4.14
518	7.44	734	6.32	1001	4.52
607	7.96	853	6.80	1160	4.87
707	8.17	982	7.09	1296	5.23
796	8.48	1112	7.31	1433	5.51
891	8.65	1209	7.67	1569	5.72
974	8.89	1328	7.86	1706	5.96
1030	9.07	1393	7.95	1865	5.94
		Medium range			
334	7.48	464	6.49	591	4.93
568	8.78	777	7.75	1023	5.71
807	9.28	1080	8.36	1387	6.32
1041	9.59	1371	8.78	1751	6.68
1286	9.68	1695	8.89	2115	6.91
1520	9.86	1965	9.17	2457	7.14
1782	9.86	2278	9.25	2775	7.36
2021	9.86	2570	9.36	3094	7.57
2283	9.86	2851	9.50	3412	7.71
2506	9.86	3034	9.56	3662	7.77
		High range			
557	8.58	766	7.54	910	6.16
1030	9.27	1404	8.21	1592	7.03
1509	9.44	2019	8.55	2297	7.32
2060	9.27	2612	8.83	2980	7.54
2629	9.10	3240	8.89	3662	7.65
3626	7.90	3931	8.78	4459	7.55
4177	7.38	4752	8.49	5118	7.68
		5648	8.14	5892	7.61
		7452	6.95	6734	7.49
		10584	5.00	8053	6.96
				9122	6.76
				10214	6.60
				11011	6.61
				12012	6.36

Hercules Viscometer

The Hercules viscometer operates on very much the same principles as the Hagan with the exception that the torque measuring system in the Hercules depends upon spring displacement whereas the Hagan torque measuring system consists of a pneumatic balancing device. Calibration of the spring is accomplished on the instrument, thus taking into account bearing friction, by suspending weights attached to a cord which is wound around the cup receiver from an essentially frictionless pulley and determining the torque spring constant in dyne centimeters per unit deflection. The spring constant thus obtained for the instrument used in these tests was 107,438 dyne cm. per cm. deflection. In addition to the spring constant it is necessary to calculate an instrument constant, S, and the rate of shear for each bob. The values for the instrument constant and the rate of shear appear in Table V.

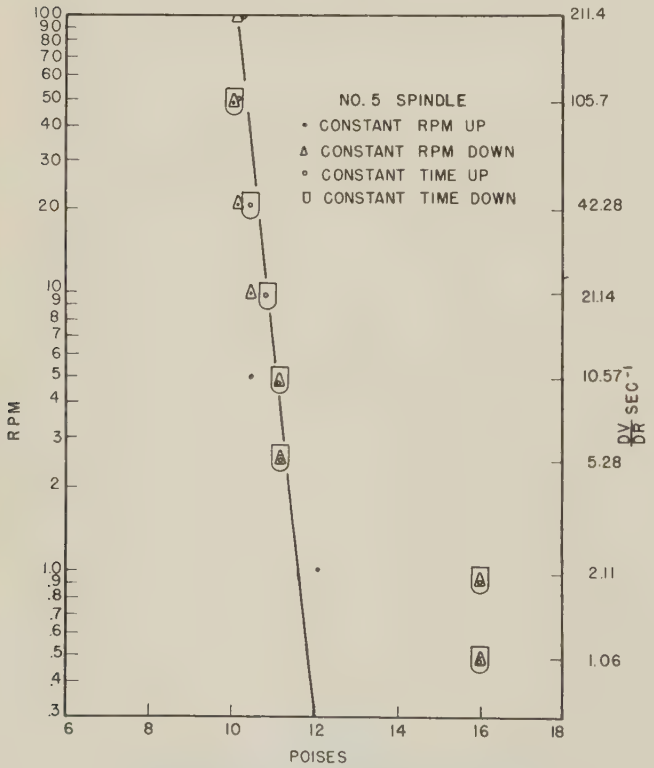

Fig. 5. Variation in apparent viscosity with log of revolutions per minute; Brookfield viscometer

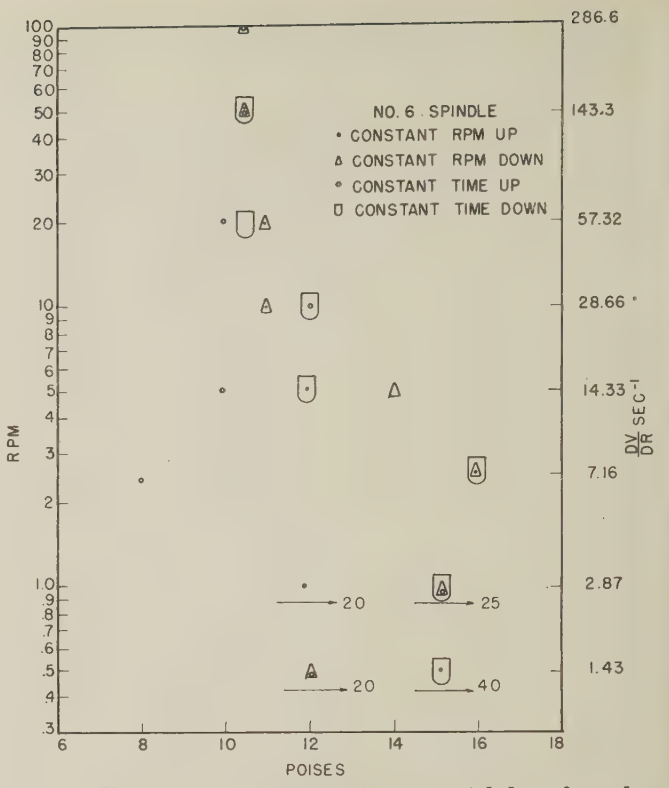

Fig. 6. Variation in apparent viscosity with log of revolutions per minute; Brookfield viscometer

The instrument constant is calculated from equation (4) and the rate of shear dv/dr is calculated by the method of Green (7) where:

$$\frac{dv}{dr} = \frac{W}{2\pi r^2 h S} \qquad (8)$$

where
$\frac{dv}{dr}$ = rate of shear, reciprocal seconds
W = angular velocity (radians per second)
where
r = radius in centimeters at which dv/dr is evaluated
h = height of bob in centimeters
S = instrument constant

Table V. Instrument Constants for Hercules Viscometer

	Bob no. 1	*Bob. no. 2*
Cup radius, cm.	2.002	2.002
Bob radius, cm.	1.945	1.945
Bob height, cm.	4.674	2.489
S	0.0002567	0.0004821
$\frac{dv}{dr}$	$\frac{W}{0.02937}$	$\frac{W}{0.02937}$

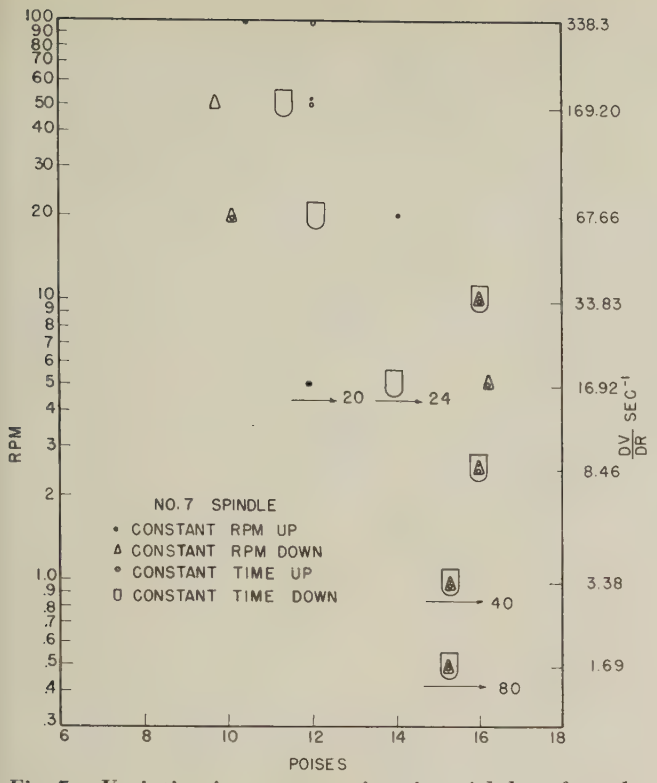

Fig. 7. Variation in apparent viscosity with log of revolutions per minute; Brookfield viscometer

As previously stated (7) an average radius determined by $(R_c + R_b)/2$ can be substituted for r when R_b/R_c approaches unity in which case equation (8) becomes:

$$\frac{dv}{dr} = \frac{W}{2\pi h S \dfrac{(R_c + R_b)^2}{2}} \qquad (9)$$

Equation (9) differs from equation (6) only in that:

$$W = (W_{sk})(\text{scale reading})$$

The viscosity u is calculated from the method of Green (*4*).

$$u = \frac{9.55(T - T_2)S}{\text{r.p.m.}} \qquad (10)$$

where

u = viscosity in poises
9.55 = constant (9.55 radians/sec. = 1 r.p.m.)
T = torque in dyne centimeters
T_2 = torque at intercept of torque axis
S = instrument constant
r.p.m. = revolutions per minute

When dealing with a Newtonian fluid T_2 is equal to zero since the intercept of the torque curve is at the origin and equation (10) becomes:

Table VI. Hercules Viscometer Viscosity in Poises
(1000 centistoke Dow Corning 200 fluid)

Bob no. 1		Bob no. 2	
$\frac{dv}{dr}$ 1/sec.	u (*poises*)	$\frac{dv}{dr}$ 1/sec.	u (*poises*)
306.6	10.720	306.6	10.355
613.1	9.954	613.1	9.779
919.7	9.802	919.7	9.586
1226.3	9.802	1226.3	9.634
1533.1	9.679	1533.1	9.549
		1839.4	9.490
		2146.0	9.453
		2452.6	9.491
		2759.2	9.459

$$u = \frac{9.55(T)(S)}{\text{r.p.m.}} \qquad (11)$$

The results obtained using the Hercules viscometer are listed in Table VI.

DISCUSSION OF RESULTS

Rheograms of coating colors are usually plotted on x-y coordinates as torque versus revolutions per minute. The rate of shear dv/dr can be readily substituted for revolutions per minute for the Hercules and Hagan and it can also be done for the Brookfield using the method suggested under the procedure for the Brookfield viscometer. This has been done on the right-hand ordinate of Figs. 1 to 7. Because the material tested is theoretically Newtonian the substitution of viscosity in poises for torque should result in the obtaining of straight lines independent of rate of shear intersecting the viscosity axis at the actual viscosity of the material being tested. Figures 1 through 7 indicate that this is true for the Brookfield viscometer for spindles 2 and 3 for both constant speed and constant time intervals between measurements and also true for spindle 4 for the constant speed measurement. Spindle 2 gives a viscosity of 9.5 poises at constant rpm. Figure 4 also indicates that a difference in viscosity is indicated when readings are taken at constant speed and constant time interval. While the constant revolutions per minute still indicate a viscosity of approximately 9.6 poises, the constant time interval indicates a viscosity of 12.5 poises, a difference exceeding 20%. Figure 5 indicates a viscosity of 11.3 poises at constant speed and 12.1 poises at constant time. Figure 1 indicates a viscosity of 12.2 poises at constant speed and 10.3 poises at constant time. Figures 6 and 7 are so badly

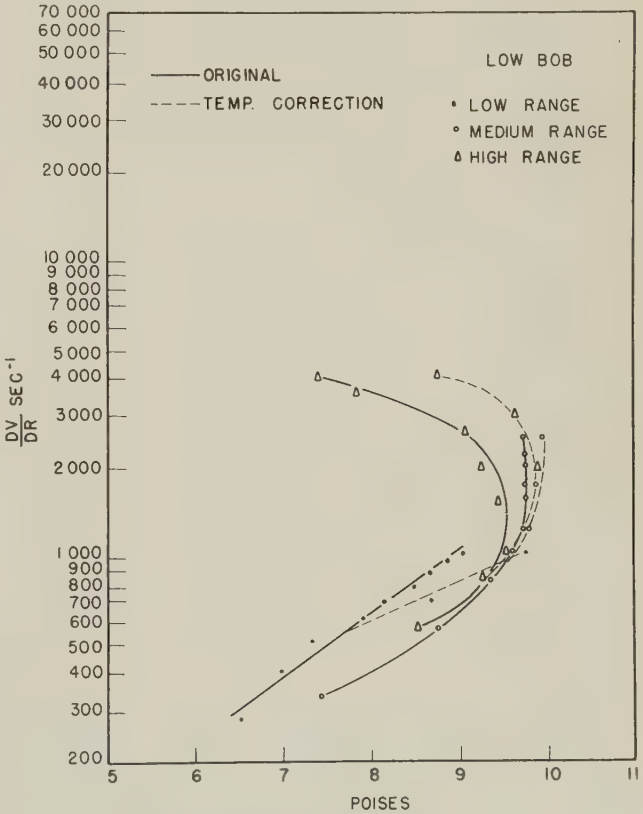

Fig. 8. Variation in apparent viscosity with log of rate of shear; Hagan viscometer

scattered as to preclude the prediction of any particular viscosity.

Inspection of the original data (Tables VII and VIII) indicates that spindles 1, 6, and 7 are not in the proper range for the material being tested. The maximum value obtained with spindle 7 was only 3.0% of the total range of the instrument scale. Other values obtained as low as 0.1% of the instrument range are subject to considerable doubt as to their accuracy. In a manual (*8*) accompanying the Brookfield viscometer the following statement is made:

"If the test material is non-Newtonian, a series of preliminary tests will be necessary to see which spindle and speed should be chosen as a future standard. We suggest that a spindle be selected for this work which will produce the maximum on-scale reading at the instrument's top speed. (This will permit shear stress-rate of shear curves of maximum sensitivity to be made.) If this preliminary work shows that the material may be specified by measurement at one speed rather than by measurement at a number of speeds (this may not be the case with many non-Newtonians) the use of another spindle may be indicated. This spindle should be selected so that an acceptable product will produce a reading of about 50% of full scale at the desired speed. It will be necessary to include data noting the spindle and speed in your specification."

Spindle 3 as indicated by Fig. 3 fulfills the conditions of the first portion of this paragraph and gives a satisfactory viscosity measurement. Spindle 4 fulfills the conditions of the second portion of this paragraph and gives a satisfactory reading at constant speed but not at constant time. Spindle 2 (Fig. 2) also gives a satisfactory result although it is not possible to obtain maximum revolutions per minute before exceeding the range of the instrument.

As indicated by Figs. 1 through 7 values at the lower end of the revolutions per minute range are

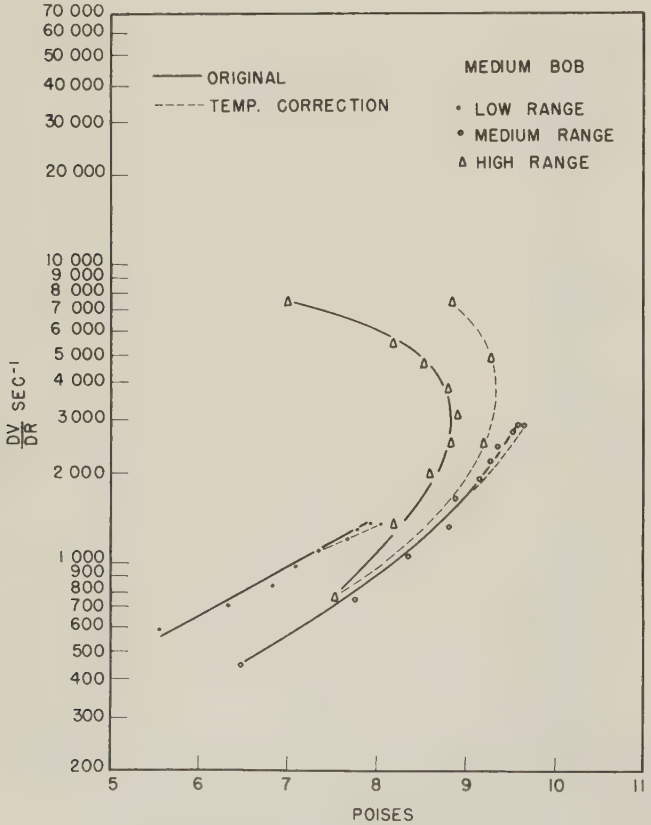

Fig. 9. Variation in apparent viscosity with log of rate of shear; Hagan viscometer

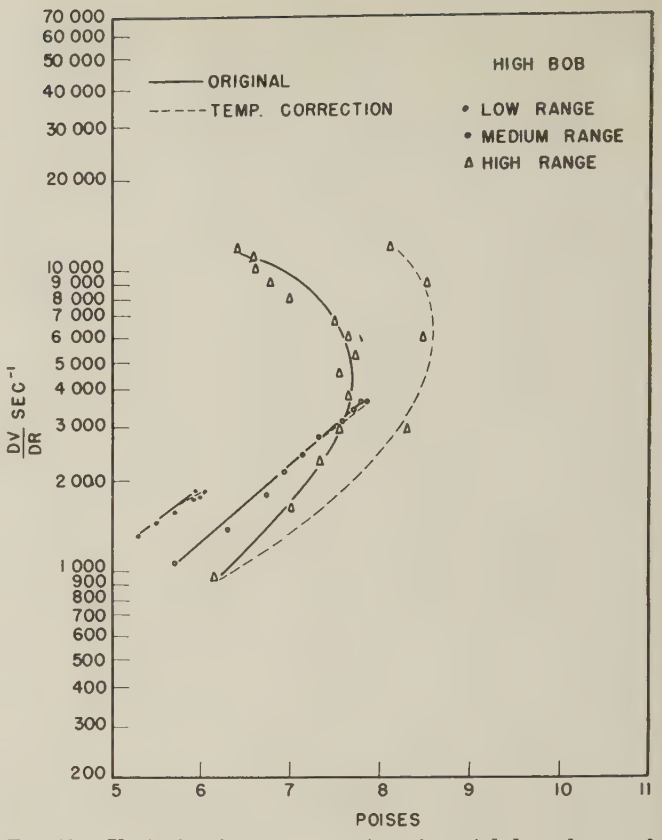

Fig. 10. Variation in apparent viscosity with log of rate of shear; Hagan viscometer

neither reproducible or accurate and the selection of higher revolutions per minute is to be recommended. In using the viscometer to evaluate paper coating colors and non-Newtonian materials it behooves the user to plot a series of graphs using each spindle at both constant speed and constant time interval and then determining by inspection which spindle and which recording method will give him the most information about his particular product. While the constant time interval does not appear to give the best results from the above data it may well be the proper method to use on paper coating colors in order to establish the degree of thixotropy present in the color.

Figures 8, 9, and 10 represent the results obtained when the data of Table IV are plotted in a fashion similar to Fig. 1 through Fig. 7.

Table VII. Brookfield Viscometer Instrument Reading, % of 100 Scale Constant R.P.M. Interval
(1000 centistoke Dow Corning 200 fluid)

r.p.m.	Spindle no. 1	2	3	4	5	6	7
0.5	5.9	1.4	0.6	0.4	0.2	0.2	0.1
1.0	11.5	2.5	1.0	0.5	0.3	0.2	0.1
2.5	33.7	6.3	2.4	1.2	0.7	0.4	0.1
5.0	67.7	12.3	4.7	2.3	1.3	0.6	0.25
10.0	N.R.	24.8	9.4	4.6	2.6	1.1	0.4
20.0	N.R.	49.8	18.9	9.0	5.1	2.2	0.7
50.0	N.R.	N.R.	47.5	22.9	12.5	5.2	1.5
100.0	N.R.	N.R.	95.4	45.7	25.3	10.4	2.6
50.0	N.R.	N.R.	47.7	22.8	12.5	5.2	1.2
20.0	N.R.	49.8	19.0	9.0	5.1	2.2	0.5
10.0	N.R.	24.8	9.5	4.6	2.6	1.1	0.4
5.0	67.7	12.3	4.7	2.3	1.4	0.7	0.2
2.5	34.0	6.4	2.4	1.2	0.7	0.4	0.1
1.0	13.4	2.5	1.0	0.5	0.4	0.25	0.1
0.5	6.7	1.4	0.5	0.3	0.2	0.1	0.1

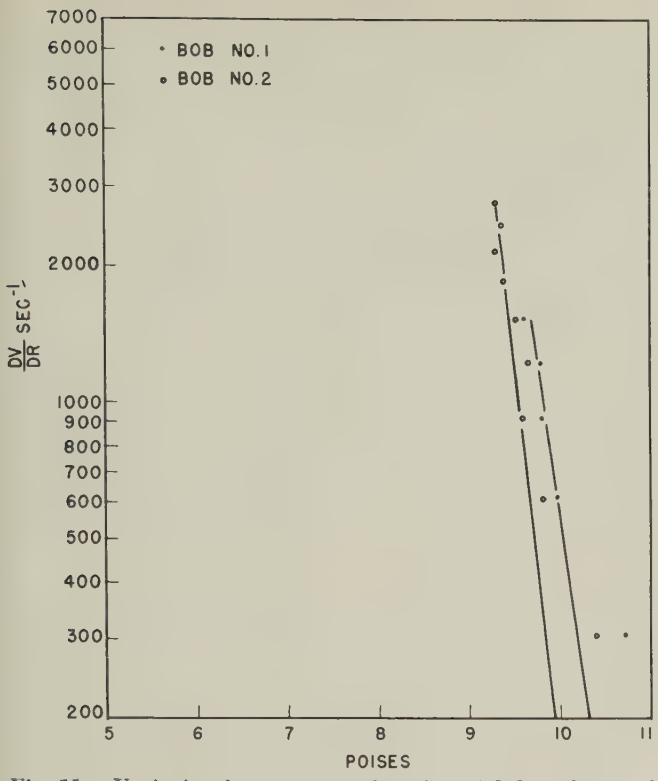

Fig. 11. Variation in apparent viscosity with log of rate of shear; Hercules viscometer

It appears from an inspection of these curves that a constant viscosity value has not been reached. The sloping straight lines represent the low torque range of the instrument and the viscosity of the material being tested was so high that only 18% of the maximum shear could be applied before reaching 100% of the torque scale when using the low shear bob. The maximum shear used with the medium shear bob was 12% and with the high shear bob only 7%. Slight errors in zeroing the instrument and reading the values at the lower end of the range can conceivably account for the low values of viscosity. With all three bobs the value of the low torque range appears to be approaching the correct value when the instrument reached maximum torque scale reading.

The medium and high range bob curves parallel one another very closely, however, the high bob curve is, in all cases, displaced to the left approximately two poises in the range of maximum viscosity. All tests were run with fresh samples, starting at the same temperature.

Table VIII. Brookfield Viscometer Instrument Reading, Per cent of 100 Scale—Constant Time Interval
(1000 centistoke Dow Corning 200 fluid)

	Spindle no.						
r.p.m.	1	2	3	4	5	6	7
0.5	5.2	1.3	0.5	0.4	0.2	0.1	0.1
1.0	11.2	2.5	1.0	0.5	0.4	0.25	0.1
2.5	28.4	6.2	2.4	1.2	0.7	0.2	0.1
5.0	58.5	12.3	4.7	2.4	1.4	0.5	0.2
10.0	N.R.	24.6	9.3	4.7	2.7	1.2	0.4
20.0	N.R.	49.6	18.7	9.3	5.2	2.0	0.5
50.0	N.R.	N.R.	47.4	23.4	12.8	5.2	1.5
100.0	N.R.	N.R.	94.8	46.8	25.7	10.4	3.0
50.0	N.R.	N.R.	47.4	23.5	12.7	5.2	1.4
20.0	N.R.	49.6	18.8	9.4	5.2	2.1	0.6
10.0	N.R.	24.7	9.4	4.7	2.7	1.2	0.4
5.0	58.7	12.4	4.7	2.4	1.4	0.6	0.3
2.5	28.7	6.2	2.4	1.2	0.7	0.4	0.1
1.0	11.2	2.5	1.0	0.5	0.4	0.25	0.1
0.5	5.6	1.2	0.6	0.4	0.2	0.2	0.1

Upon checking the temperature of the material in the cup at the end of the high shear bob run at high torque range an increase in temperature of 3°C. was noted. The temperature coefficient of viscosity of 1000 centistoke Dow Corning 200 fluid over the temperature range 28 to 157°F. is 0.1162 poises per °F. (*9*). If this correction is applied to the maximum rate of shear value obtained in Fig. 10 the apparent viscosity becomes 6.99 poises. The maximum increase in viscosity obtainable as a correction for Figs. 8, 9, and 10 from a temperature increase of 3°C. of the bulk of the material in the cup is only 0.63 poises.

If however the temperature of the material clinging to the bob, which is essentially the material present in the annular space when a test is being conducted, is measured by allowing it to drain onto the bulb of a thermometer the temperature increase observed is 8.2°C. This represents a decrease in viscosity, from the stated value, of 1.72 poises. Upon adding this to the value of 6.36 poises obtained at the maximum rate of shear on Fig. 10 we obtain an apparent viscosity of 8.08 poises. Since some loss of material occurs as the bob is removed from the cup and since some heat is continually being absorbed by the bob the actual temperature increase must be higher than any of the observed values.

Weltman and Kuhns (*10*) have developed a mathematical method for compensating for temperature increases but it requires knowledge of the temperature of the bob and the temperature of the cup. Using their method they found that the calculated viscosity of a 600-poise silicone oil ranged from 540 to 565 poises whereas the observed experimental value was only 255 poises. Some of this large difference was attributed to thixotropic breakdown of the high viscosity oil and the rest to temperature effects in the viscometer.

For each bob of the Hagan viscometer the degree of curvature increases and the viscosity decreases as the time interval before reaching maximum torque gets longer for the particular range involved. The curvature may be attributed to continually decreasing viscosity with increasing temperature. The temperature increase results from heat generated by the continuous shear of the material in the annulus.

Table IX. Viscosity Correction—Hagan Viscometer

	Low bob		Medium bob		High bob	
% Scale	Temp. rise, °C.	Mu	Temp. rise, °C.	Mu	Temp. rise, °C.	Mu
			Low Range			
0	0	0	0	0	0	0
25	0	0	0	0	1.4	0.29
50	0	0	0.2	0.04	2.4	0.50
75	2.1	0.44	0.4	0.08	4.3	0.90
100	3.3	0.69	0.7	0.14	6.9	1.44
			Medium Range			
0	0	0	0	0	0	0
25	0	0	0	0	2.2	0.46
50	0	0	0	0	4.4	0.92
75	0	0	0	0	7.2	1.51
100	0.5	0.1	0.2	0.04	7.5	1.61
			High range			
0	0	0	0	0	0	0
25	0	0	0	0	3.1	0.65
50	0	0	0	0	4.9	0.92
75	0	0	0	0	7.2	1.51
100	0.4	0.08	0.3	0.06	8.2	1.72

An attempt has been made in Figs. 8, 9, and 10 to show the corrections which can be made if the temperature increase is known. Individual trials were made with each bob at each range, stopping each trial at 25, 50, and 75% of the full scale deflection for the appropriate bob and range. The bob was quickly removed and the temperature of the material clinging to the bob was noted. The corresponding viscosity correction was made and added to the observed viscosity.

Table IX shows the temperature rise and the corresponding viscosity correction.

The dotted lines on Figs. 8, 9, and 10 represent the corrected curves. It will be observed in all cases that the curvature is reduced and the viscosity more nearly approaches a constant value. Had it been possible to obtain the exact temperature in the annulus an even closer approximation to a straight line would have been realized.

It is important to realize (as in the case of the Brookfield viscometer) that certain of the bobs and ranges used were not in the proper range for the material being tested. Consequently, the results obtained for the low torque range and to some extent for the medium torque range are not valid.

Figure 11 represents the data of Table VI for the Hercules viscometer. Bob no. 1 indicates a viscosity of 10.25 poises while bob no. 2 indicates a viscosity of 9.9 poises. The temperature effect noticeable in the Hagan instrument above 2500 reciprocal sec. does not appear to be present to any great extent however only one data point was obtained with the Hercules above the value of 2500 sec.$^{-1}$. In addition the cup and bob of the Hercules are made of steel whereas the cup of the Hagan is made of aluminum and the bob of steel. This difference represents a heat capacity for the Hercules of approximately twice that of the Hagan. Consequently, considerably more heat which is generated can be stored in the Hercules and will not appear as a temperature increase in the material being tested. The slope of the curves obtained with the Hercules viscometer does indicate the presence of some slight temperature effect since there is a decrease in viscosity with increasing rate of shear; however, no temperature increase was noted when the samples were checked immediately after running.

Low values at low rates of shear are not present. A certain amount of inertia present in the system has a tendency to cause the torque recording system to start with a slight jerk thus giving an erroneously high value at the initial low shear rate.

CONCLUSIONS

The material chosen for these tests is considered superior for having a viscosity that is nearly independent of temperature and for approaching the ideal Newtonian fluid. The danger of high shear rates without adequate temperature control or temperature compensation is obvious.

The proper selection of an instrument range or spindle requires a series of carefully conducted tests wherein that graph giving the most information about the product being tested is selected as the basis for future tests and comparisons.

A sequel to this work should be a continuation with standard non-Newtonian and thixotropic materials.

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Controlling Corrosion in a Modern Magnesia-Base Sulphite Mill

J. E. FINSEN

Before the Ketchikan Pulp Co. magnesium bisulphite mill went into operation in 1954, type 316 stainless steel was considered a "standard" of the industry. In this mill, however, it did not perform according to expectations and premature failures occurred in fabricated piping and equipment. With a closed system for recovery of chemicals, injurious chlorides were not removed as expected. In fact, they were actually concentrated to critical levels with respect to the corrosion resistance of stainless steels. This paper has outlined the forms of corrosion encountered and experiences in the control of corrosion which have resulted in the adoption of rigid specifications for material quality, design details and fabrication procedure. The variety of stainless steels now available, if wisely selected and properly applied, provides a practical and effective material of construction for modern acid pulping systems.

BASED upon years of successful experience in many sulphite mills, and extensive research in the magnesia-base process, the designers of the new mill at Ketchikan, Alaska, confidently specified type 316 stainless steel for acid and liquor service. More than the usual amount of stainless was used throughout the mill to avoid excessive maintenance due to corrosion, and to insure a minimum of metallic contamination of the high quality dissolving grades of wood pulp.

Almost immediately, stainless steel equipment began to fail, and it was soon apparent that corrosion rates

J. E. FINSEN, Ketchikan Pulp Co., Ketchikan, Alaska.

were considerably higher in some areas of this mill than would normally be expected. Investigation of factors that might cause the media to be abnormally corrosive established that the level of chloride concentration was considerably higher than that observed in other mills. This was caused by recycling of chlorides brought into the closed system by chips cut from salt water borne logs. Equipment incorporated in the design of the chemical recovery system included a washing stage for removal of such soluble material from the recovered ash. It was discovered, however, that the physical character of the chlorides, as carried in the combustion products, is such that very little is separated with the ash. They are, instead, carried through the multiclones as a fume, and recovered with the combustion gases. This was an unexpected complication, and a practical method of isolating and removing chlorides from the system has not, as yet, been conceived. The resulting high level of chlorides is an important factor in the premature failure of stainless steel by corrosion in this mill.

It is generally believed that the stainless steels owe their outstanding corrosion resistance to a passive condition created by the formation of an invisible protective surface film. Present knowledge of films indicates that they consist of one or more layers of oxygen, metal oxides, or other compounds. The layers are considered to be chemisorbed rather than physically attached, and to be bonded by the secondary valence forces of the metal, thereby rendering the surface less reactive in certain environments (*1*). In most cases this theory of passive films provides a satisfactory and logical basis for considering the effects, causes, and cures of the various forms of corrosion attack associated with the magnesium bisulphite pulping process. All of the austenitic stainless steels form passive films when exposed to the action of oxidizing acids, but in most nonoxidizing acid solutions the straight chromium-nickel alloys corrode actively. The addition, however, of appropriate amounts of certain elements, such as molybdenum and silicon, to properly balanced chromium-nickel alloys improves their resistance to a larger variety of acid solutions (*2*). Types 316 and 317 stainless steels are among the better film-forming alloys and have become widely used in acid pulping systems because of their ability to maintain passivity in sulphite acids.

Chlorine ions interfere with the formation of passive films and tend to break down films already formed; perhaps by penetrating the film and breaking its bond with the metal, or by peptizing the film material. Therefore, it is not surprising to find that the better film-forming alloys are required to maintain passivity in the presence of chlorides. In very high concentrations, complete passivation is difficult or may be impossible (*3*).

PIT CORROSION

Stainless steel is particularly susceptible to pitting in a chloride environment. Pitting is characterized by rapid penetration in small areas located at random on a surface which otherwise frequently remains unaffected. It is believed that the pits are caused by a breakdown of the film at certain favored nuclei, thereby creating electrolytic cells with minute anodic areas of active metal surrounded by relatively large areas of passive cathodic surface. Current density at the relatively small anodic area is high, and penetration proceeds rapidly. The original break may occur at weak spots in the film caused by surface defects such as nicks, scratches, or minute particles of foreign material.

Knowing these facts, it is not surprising that pitting was severe in units of the red liquor evaporators handling concentrated liquor. The effects of high concentrations of chlorides were further aggravated by the accelerating effect of the high temperatures required in these units.

In spite of this vicious environment, it was noted that some stainless parts were relatively free of attack, while others were totally destroyed. This inconsistency of performance was particularly prominent in heat exchanger tubes and in valve castings. A study of heat analyses of the tube material indicated that the heats were reasonably uniform in most respects, but suggested that rather wide variations existed in percentages of molybdenum. The variations ranged between 1.98 and 2.36%. Suspicion that molybdenum content had considerable influence on performance was verified by chemical analyses of tubes which had failed in service. Of those tested, all were found to contain less than 2.2%. Replacement tubes with molybdenum in the range of 2.27 to 2.47% proved to be definitely more resistant to pitting and those containing about 3% were even better.

The influence of molybdenum on pitting was even more pronounced in valve castings. A number of valves became unusable in a short period of time due to corrosion of internal parts. Here again, material that failed was found, without exception, to be deficient in molybdenum. A few valve disks were almost completely destroyed by profuse pitting. They were found to be well below 2% molybdenum.

Such deficiencies were due, in part, to the fact that much of the equipment in this mill was manufactured during the Korean crisis, when Government regulation of critical material required the limiting of molybdenum and other strategic metals to a bare minimum.

Pit corrosion in the evaporator plant has been reduced to negligible proportions by adopting the following measures: A minimum of 2.75% molybdenum has been specified on all replacements. Particular care is practiced in the handling of stainless sheets to avoid such potential pit nuclei as scratches, nicks, and other surface scars. All surfaces are passivated before exposure to spent liquor to stabilize films and dissolve any ferrous particles that might be left on surfaces by carbon steel tools used in fabrication. The equipment is washed regularly with acid condensate, and periodically given a caustic boilout to prevent formation of pit-inducing surface scale. It was also possible to diminish the aggressiveness of the concentrated liquor in the evaporators by buffering with magnesia to reduce the ion activity of the liquor. The pH value is now maintained above 3.5.

STRESS CORROSION CRACKING

It is well known among students of corrosion that chloride solutions have a tendency to promote stress corrosion cracking in the austenitic stainless steels. As the name implies, it occurs only in stressed metal and while it may be caused by static tensile stress of

great magnitude, it is usually confined to material subject to cyclic stresses. The stress repetitions may be of either high or low frequency. Failure may be expected much sooner, however, where high frequency vibration occurs. These failures are similar to mechanical fatigue in metals, but are accelerated by the presence of chlorides.

A typical stress corrosion crack develops as a transgranular fracture and propagates in an irregular branched path through the metal. Frequently there is no other visible indication of corrosion attack. When cracking is combined with some other well-defined form of corrosion, it is usually a secondary effect and may occur under negligible stress conditions. Advanced intergranular corrosion is an example; attack at the grain boundaries, in this case, may destroy the physical properties of the alloy to such an extent that it virtually falls apart under its own weight. Cracks of this type should not be confused with the distinctive stress corrosion crack.

Considerable stress cracking has been experienced in acid and liquor piping where frequent and abrupt temperature changes occur, and provisions for thermal expansion were inadequate to prevent repetitive strains in the piping. Cracking has been particularly severe in locations where hydraulic pulsations set up vibration in piping, and where severe shock occurs frequently. It is suspected that many premature fractures in pump impellers and shafts were accelerated by the effects of stress corrosion also.

In contrast to other forms of corrosion, stress corrosion is likely to occur in all grades of the austenitic stainless steels, and variations in chemical composition of the alloy have little effect on resistance to cracking.

It has been possible, in most cases, to eliminate stress cracking in piping systems by careful consideration of design details. Pipe walls must be sufficiently heavy to resist "flutter" due to hydraulic pulsations, and to keep tensile stress, induced by internal pressure, to low values. Piping should be well aligned, properly supported, and arranged to provide for dissipation of thermal expansion without strain.

Much research has yet to be done in stress corrosion. At present, it appears that the only variable that can be controlled is stress itself if the chlorides, or their effect, cannot be eliminated.

INTERGRANULAR CORROSION

Corrosion at the grain boundaries is a special type of attack found in the austenitic stainless steels. It is greatly influenced by the analysis and heat treatment of the metal. If these alloys contain more than about 0.03% carbon and are not stabilized by appropriate additions of strongly carbide-forming metals, such as columbium or titanium, they become sensitive to attack at the grain boundaries after a short period of exposure to certain critical temperatures. When heated in the range of 800 to 1600°F., carbon tends to migrate to the grain boundaries where it combines with chromium to form chromium carbide. When an alloy, thus sensitized, is exposed to a corrosive medium, minute electrolytic cells are established, with the impoverished grain boundaries becoming anodic to the interior of the crystals. Once started, the corrosion proceeds inwardly along succeeding grain boundaries, completely destroying the physical properties to the depth of attack. Surface grains are freed from the matrix to be washed away, leaving a rough, granular appearance typical of this form of corrosion. When completely penetrated, the alloy crumbles like sandstone.

Exposure in the critical temperature range is usually not a condition of service and the danger, therefore, lies in fabrication procedures such as welding, hot forming, or stress relieving. Of these, welding is undoubtedly the most common cause of sensitization, since virtually all fabrication requires some welding. In this case, attack usually occurs in a narrow band along the sides of a weld deposit, leaving the weld metal itself intact. In pressure vessels, the thinning and weakening effect of intergranular attack, working from within, acts as a stress raiser and may eventually result in the sudden rupture of the vessel at the heat-affected zone. This happens unexpectedly since no evidence of attack is seen from the outside until failure occurs.

Carbon, precipitated by welding or other heating operations, can be redissolved by means of a full anneal of the metal. This involves soaking at 1900 to 2150°F. for a period of time, depending on the mass of the section, followed by rapid cooling. This treatment allows the carbon to return to solid solution and restores the corrosion resistance of the alloy, provided it is done before exposure to a corrodant. Once attacked, the physical properties cannot be restored.

When heat treatment is not feasible, the effects of welding can be minimized by welding procedures that limit sensitizing temperature in the metal to about 1 min. These conditions can be met by developing rapid welding techniques followed by fast cooling. On very light gages, an air blast will suffice, but on heavier material the most effective cooling medium is water. It can be applied as a very small stream or spray, or by swabbing with a wet sponge or rag. Where the weld is followed by a fine stream of water at a short distance, say 5 to 7 in., continuous welding can be carried on. Otherwise, no longer than 1 min. of uninterrupted welding should be permitted. Normally, a coated rod is consumed in less than 1 min. The safe limit for continuous welding between quenches is frequently judged on this basis.

When maximum resistance to intergranular attack is required, the extra low (0.03% maximum) carbon grades are recommended. Experience indicates that these grades are virtually immune to carbide precipitation. Where heavy multipass welding with sustained high temperatures may be encountered, it is recommended that even this material be quenched.

The columbium and titanium stabilized alloys have been avoided in Ketchikan in the belief that some sacrifice would be made in corrosion resistance with these alloys.

CONCENTRATION CELL CORROSION

Stainless steel is also very vulnerable to concentration cell corrosion. Any condition which allows areas of stagnant solution to lie in contact with the metal invites this form of corrosion. It is also known as crevice corrosion, or contact corrosion, since it is frequently found in crevices or cavities between contact surfaces of two pieces of metal of the same composition. It

depends on the fact that stagnant portions of trapped corrosive media quickly change character due to the accumulation of metal salts, depletion of dissolved oxygen, or changes in concentration of other oxidizing or reducing salts. The different concentrations of the solution in contact with two areas of the metal induce a potential differential between the areas and an electrolytic cell is created. High metal ion concentrations tend to make the cavity surfaces cathodic, and the anodic areas immediately surrounding the crevice are attacked. Conversely, low oxygen concentration cells reverse the potential and the cavity surfaces become anodic. Attack is then within the crevice. Oxygen concentration cells are particularly severe on stainless steel because the absence of oxygen at the anodic surface precludes the repair of the passive film in this region. The simple original oxygen cell becomes overshadowed in importance by the much more aggressive cell established between the active metal in the anodic area and the large surrounding cathodic area of passive metal.

None of the stainless steel alloys are immune to attack by concentration cells, and extreme care must be exercised in design and assembly of equipment to avoid any obstructions to free circulation over all exposed surfaces. This form of corrosion has been the cause of many interruptions in production at the Ketchikan mill and was most prevalent in flanged joints of the fabricated piping systems. These flanges were of the conventional, lightweight lap joint type, using mild steel backing flanges. Regular pressed lap joint stub ends were used for low pressure service and for more severe service, heavier gage rings were cut from flat sheets. These were applied as slip-on flanges, welded inside and out. At best, the gasket faces of both types were far from perfect, and usually they were so badly distorted by welding that tight joints were impossible. Nonuniform compression of the gaskets allowed the acid solutions to penetrate the gasket material and set up destructive concentration cells, which soon destroyed the gasket faces and penetrated the flanges. Attempts to straighten the flanges and hand surface the gasket faces were discouraging. Even when gasket seals were satisfactory, both types left small stagnant pockets at the inner edge of the gasket. In the case of the pressed flange, the pocket was created by the radius of the formed neck, and in the heavier slip-on flanges the internal fillet weld formed the objectionable cavity. Generally, both types were unsatisfactory, and the need for an improved design was apparent. A step in the right direction was made when the lightweight cast stub-end was introduced. These flanges had the advantage of a full, machined, gasket face and, in theory, offered a solution to many of the problems. In practice, however, they also proved impractical for several reasons. They were too light for all but low pressure service, and because of their light weight and short neck, welding invariably warped them sufficiently to destroy the advantages of the machined gasket face. Even more serious is the fact that the most commonly used sizes are "shell cast" in molds using organic resins for the shell. High surface carbon pickup is an inherent property of these castings. Even the best procedure of quenching welds doesn't prevent some weld decay due to carbon, where piping is used in severe environments.

A special, heavy cast flange is now being used which has solved the problems encountered with all other flanges. They have the mechanical strength for all acid and liquor service. The flange is sufficiently heavy to prevent distortion of the machined gasket face under the most severe abuse; and the long, tapered, heavy neck precludes distortion of the gasket face by any amount of welding stress. These flanges are sand cast and can be made in extra low carbon, insuring freedom from weld decay due to carbides.

Another common location for concentration cells in fabricated pipe is associated with the welded seams. These welds are made on the outside of the pipe only, and frequently do not fully penetrate the seam, leaving a groove at the weld root and creating ideal conditions for concentration cell development.

Tongue and groove joints, sometimes used for valve bonnet seals and other flanged joints, are also subject to severe attack by crevice corrosion. This design provides a thin, deep cavity on both sides of the narrow gasket seat, which, when exposed to severe corrosive media, is almost certain to result in a concentration cell. This design should be carefully avoided in severe corrosion service. In the Ketchikan mill, equipment with tongue and groove seals has either been replaced by other designs, or the joint altered by welding and machining in such a way that free circulation is provided at all surfaces on the exposed side of the gasket seal.

GENERAL CORROSION

To effect economy in machine design, it is frequently necessary to construct the main members of equipment with carbon steel, and to protect them from corrosion by covering exposed surfaces with light gage stainless steel lagging. It is common practice to attach lagging to the carbon steel by welding. Occasionally, welds of this type are attacked by the corrosive medium and it can be assumed that this is caused by dilution of the weld by the carbon steel. Experience has shown that a minimum of three full passes of weld deposit is required to reduce contamination of the weld deposit to satisfactory limits, and when practical, even more would be desirable. It may be necessary to grind the mild steel back to accomplish this.

Another likely condition for rather severe corrosion is known as the "splashing effect" or "hot wall corrosion." This occurs when metal surfaces are alternately wetted by acid solutions and dried by hot gases. The action allows acids to concentrate on the surface and can destroy the best of the stainless alloys under some conditions. An outstanding example of this condition was found in the recovery gas cooling tower in which the packing is supported by stainless steel beams and gridwork. In some areas, the grids were destroyed and the beams seriously attacked. The obvious cure in this case was the installation of a group of inverted auxiliary showers under the supports to wash continually all metal surfaces. Where washing cannot be applied successfully, it would be advisable to provide for occasional replacement of affected parts, or to select more resistant material for construction.

CONCLUSION

In general, the well-known stainless steels can be used successfully in magnesium base, closed recovery, pulping systems. However, performance may be

borderline in some applications and great care must be used in selection of alloys, with particular attention focused on molybdenum and carbon content, to insure the best performance for each application. Equipment design must be scrutinized to avoid any stagnant regions, high tensile stress, and excessive vibration. Rigid control of fabrication and welding techniques is necessary to minimize carbide precipitation, weld dilution, and residual stresses. Finally, process control can do much to keep the aggressiveness of the corrosive media at safe levels in certain critical areas.

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Sulphidity Control with Elemental Sulphur

HARRY C. MARTIN

A process is described for the introduction of elemental sulphur to the kraft liquor system. This process consists of the reaction of the sulphur with a small amount of white liquor, or caustic and the introduction of the solution into the black liquor as it leaves a wet bottom of the electrostatic precipitator. This method of sulphur addition has certain advantages over either the suspension of sulphur in black liquor or its solution in cooking liquor at the digester.

Prior to the development of modern methods of pulp washing and the use of fume collectors on the recovery furnaces, the make-up requirement in the kraft industry was so large that no problem was experienced in maintaining the desired sulphidity. Twenty years ago, sulphidities* in the range of 30 to 35% were common in the industry and these sulphidities were maintained even with the use of sodium carbonate as part of the chemical make-up. However, with the introduction of pressure washers and successful vacuum washers about that time the chemical make-up was reduced and there was a corresponding reduction in the sulphidity. The introduction of fume collectors on the recovery furnaces further aggravated the problem of maintaining sulphidity because the recovered chemical consisted only in part of sodium sulphate; part of it was sodium carbonate. The experience of this mill is shown in Table I. While the actual numbers will differ from mill to mill, it is believed that these data are typical of the southern kraft industry.

Because these improvements in the recovery system have so drastically reduced the soda make-up, the introduction of elemental sulphur into this system to maintain the sulphidity has become widespread practice. Curiously, very little has been published in this regard.

Basically, two methods of introducing the sulphur are commonly used. One is the solution of sulphur in the cooking liquor. This is done either by adding the sulphur directly to the digester charge, by dissolving the sulphur in the cooking liquor before the liquor is run into the digester, or by dissolving the sulphur in the green liquor. The other method involves the introduction of sulphur prior to the recovery furnace. In this latter case, the sulphur may be mixed with the salt cake dry, it may be separately suspended in the black liquor, or the sulphur may be dumped directly into the furnace. Both of these methods have been tried at this mill and were considered unsatisfactory.

If the sulphur is added to the digester charge, the routine cooking liquor analyses do not reflect the sulphidity improvement that results from the use of sulphur.

In addition, some handling problems were involved, but, fundamentally, we were concerned about the reaction products of the sulphur and the caustic soda. It is curious that this reaction, which has been known since the 13th century, having been described at that time by Albertus Magnus, has not been more thoroughly investigated. Mellor (*1*) has this to say: "the reaction between alkali hydroxides and sulphur is complex; probably sulphides are first formed from which thiosulphates are produced, and by the dissolution of more sulphur, polysulphides; the thiosulphates lose part of their sulphur forming sulphites. In the more concentrated solution of sulphur, part of the latter appears to be uncombined because these solutions yield sulphur to hot benzene."

Wells (*2*) states that work done at The Institute of Paper Chemistry would indicate that when sulphur is added to the chips the following equation obtains:

$$6\,NaOH + 4\,S = 2\,Na_2S + Na_2S_2O_3 + 3\,H_2O$$

and that degrees of sulphidity up to any considered desirable in kraft cooking may be obtained. The reaction between elemental sulphur and sodium hydroxide is further elucidated under certain conditions in recent patent granted to Terziev (*3*). Several different reactions between sulphur and caustic soda can be found in the literature.

In any event, only part of the sulphur used forms sodium sulphide; of necessity part of the sulphur must be oxidized to one or more of the oxysulphur compounds and probably some polysulphide is formed. If sodium sulphide is considered the desired product, then the process is inefficient with respect to the use

Harry C. Martin, Technical Superintendent, Paper Mill, Forest Products Div., Olin Mathieson Chemical Corp., West Monroe, La.

* Throughout this paper "sulphidity" is expressed as the percentage of the total titratable Na_2O that is present as Na_2S.

Table I. Changes in Make-Up Chemical Requirements with Improvements in Recovery Equipment

	1936	*1942*	*Feb., 1949*
Salt cake[a]	349	256	149
Soda ash[a]	67	39	0
Sulphur[a]	0	0	1.9
Sulphidity, %	31.5	21.1	17.4

[a] Pounds used per ton of kraft paper produced.
Equipment in use during periods shown:
1936—Very unsatisfactory vacuum washers; no fume collection.
1942—Pressure washers; no fume collection.
Feb., 1949—Pressure washers; electrostatic precipitators.

of sulphur. Furthermore, conflicting opinions have been published respecting the effect of these other compounds on digester corrosion. At the time this work was undertaken, we considered these compounds undesirable in that respect.

Our trials with the introduction of elemental sulphur to the recovery furnace indicated that such use was accompanied with high losses. The characteristic blue flame of burning sulphur was visible in the furnace and the characteristic odor pervaded the recovery room. More to the point, the resulting sulphidity of the cooking was less than we anticipated. Vassie (*4*), described a method for the introduction of molten sulphur to the recovery furnace. No doubt this process results in a much improved efficiency of sulphur utilization; however, it is accompanied by certain problems in regard to equipment and corrosion.

With the background of our experience with both of these methods of sulphur introduction, T. R. Moore, at that time vice-president and general manager of the Brown Paper Mill Co., Inc., conceived the idea that a satisfactory solution might be achieved by combining the best features of the two methods. In brief, his idea was to react the sulphur with white liquor and to then reduce the compounds formed to sodium sulphide in the recovery furnace. By forming compounds of the sulphur and the caustic, it was thought that the sulphur would then be less apt to form sulphur dioxide and thus escape from the recovery furnace. Semiquantitative laboratory experiments confirmed this idea. Full-scale equipment to utilize this process was installed and with only minor changes has been in successful use for several years.

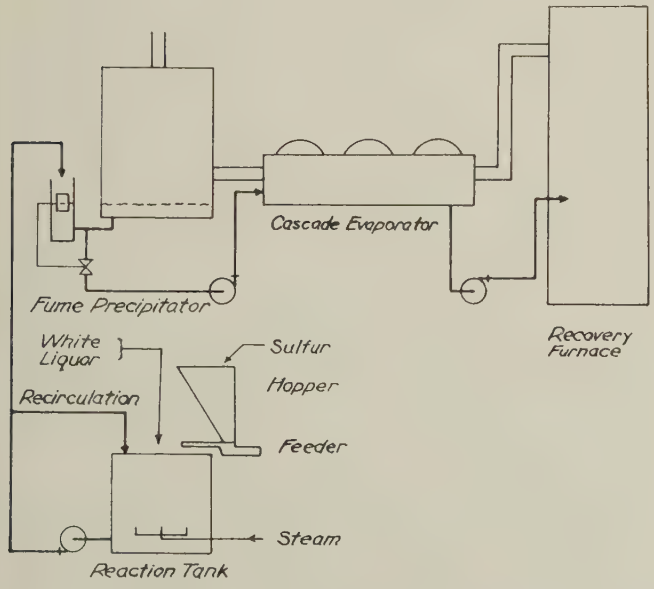

Fig. 1. Schematic flow diagram showing Moore process for introduction of elemental sulphur

Duplicate recovery furnace and precipitator, served by same sulphur reactor, omitted for simplicity

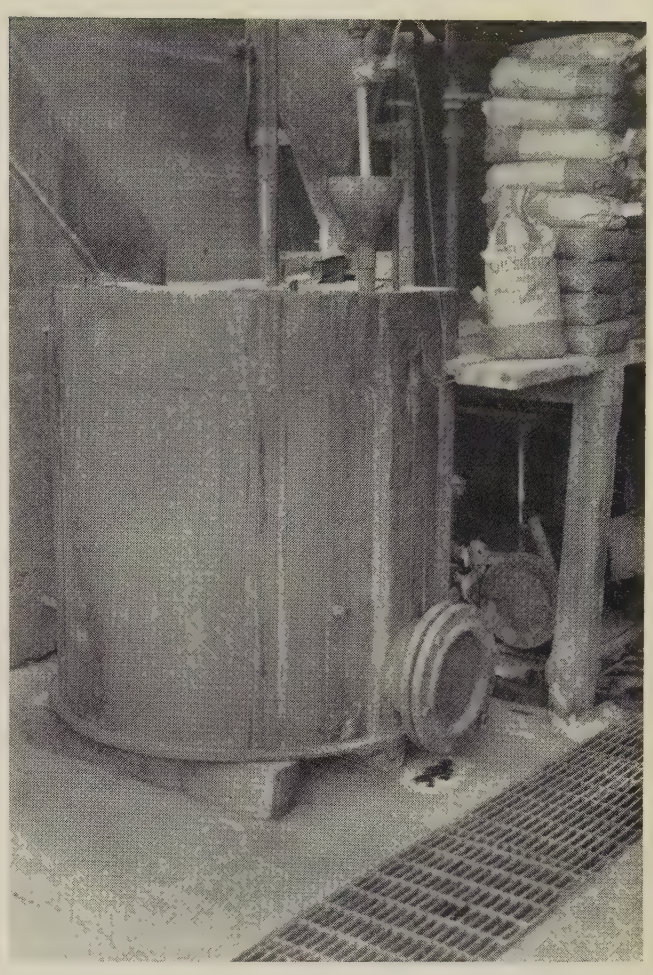

Fig. 2. Reaction tank, sulphur hopper, and feeder

DESCRIPTION OF THE PROCESS

Reference to Fig. 1 shows that the process consists of the continuous reaction of sulphur with white liquor and the addition of the resulting solution to the recovered black liquor between the precipitator wet bottoms and the cascade evaporators.

The pulp mill has a normal capacity of 700 tons per day and the equipment sizes and flow-rates given below are on that basis.

The sulphur (Olin Mathieson, soil grade, 16-mesh), is received in 50-lb. multiwall sacks. The hopper has a capacity of 400 lb. and is refilled hourly. Sulphur is fed from the hopper to the reaction tank by means of a vibratory feeder which is set at a rate of approximately 4 lb. per min.

White liquor is taken from the cooking liquor header at a rate of 8 g.p.m. This considerably exceeds the quantity required to react with the sulphur, but the

Table II. List of Equipment

Reaction vessel—carbon steel, 5 ft. 0 in. diam. by 5 ft. 0 in. high, equipped with steam distributor in bottom.
Sulphur feeder—Jeffery-Taylor No. FS-2A, $5^1/_4 \times 30$ in.
Sulphur hopper—carbon steel, capacity 400 lb. sulphur.
Circulating pump—Goulds Fig. 3705, $1^1/_2 \times 2 \times 13$ R.H., stainless steel.
Circulating line—Carbon steel, schedule 40 pipe.

excess hinders the build-up of solids in the cascade evaporators. Sufficient steam is introduced to the reaction vessel to maintain a temperature of about 220°F. This addition of steam has been found to provide sufficient agitation.

Figure 2 is a photograph showing the sulphur feeder and reaction vessel.

The liquor-levels in that wet bottom of the two precipitators are regulated by valves that are controlled by floats in standpipes. These standpipes provide a convenient and visible point of addition of the sulphur-rich liquor which is bled from the circulating line. The addition of caustic liquor to the top of the standpipes keep the float free of accumulations.

Adjustment of the sulphidity is accomplished by changes in the sulphur feed-rate of the vibratory feeder.

The equipment pertaining to this process is listed in Table II. Despite the fact that carbon steel is used throughout, with the exception of the circulating pump, there has been negligible corrosion.

The following data reflect the results obtained by the use of this process:

1957 Average Data

Salt cake make-up	143	lb. per ton[a]
Sulphur make-up	11.1	lb. per ton[a]
Sulphidity	22.9%	

[a] Basis is ton of kraft paper made. N.B. salt cake is gross amount used; the liquor inventory adjustment is negligible, the salt cake equivalent of the soda in the soap skimmings sold is about 23 lb.

The results obtained by the use of the Moore process in terms of increased sulphidity per pound of sulphur used will vary from mill to mill depending on such factors as recovery furnace operation, sulphidity, efficiency of soap separation, etc. Indeed, considerable variation has been experienced at this mill with changes in the pulp mill production rate. However, it is our belief that the process is inherently more efficient than the other methods commonly used and that it compares favorably with any of those methods in terms of operating and equipment simplicity.

When this process proved successful in full-scale operation the inventor applied for a United States patent. The application is still pending, however, the Olin Mathieson Chemical Corp., to whom the invention has been assigned, wishes to make the process available to the industry on a royalty-free basis.

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The author wishes to disclaim any contribution to the development of this process. Mr. Moore's idea was proved in the laboratory by Jack Noble; it was brought to successful application by Bruce Brooks, S. A. Elliott, and Victor Davis, Jr. These gentlemen, particularly the last named, have also assisted in the preparation of this paper.

Evaluation of Smoothness and Absorbency Tests for White Patent Coated Paperboard

JACQUELINE M. FETSKO

The available instruments and empirical tests for rating smoothness and gloss holdout properties were evaluated on 18 white patent coated paperboard samples. The statistical correlations were based on ink transfer and print gloss measurements from the letterpress printing of solids in the laboratory. For quality control purposes, the tests were examined not only for reliability but also for speed, ease of operation, and numerical results free from human error. Of the eight smoothness instruments tried, visual rating of surface photomacrographs correlated the best, but their evaluation requires human judgment. The Sheffield and the Bendtsen testers appear to offer the best compromises between the several stated requirements of routine control tests. Five types of absorbency tests, employing 11 test fluids and a variety of testing times, were investigated for their ability to predict gloss holdout. Recommended as routine control tests are the "Vanceometer," preferably 20-sec. measurements with a heavy oil, and the three ink wipe tests (Hull black, Hull red, and K and N). Tentative procedures for performing the best tests are presented. Also discussed are the limitations of the study, primarily that the correlations obtained should not be extrapolated with confidence to other grades of stock or types of printing processes.

JACQUELINE M. FETSKO, Supervisor of Printing Research, Lehigh University, Bethlehem, Pa.

PRINTING smoothness and absorbency are generally conceded to be the most important properties which comprise the printability of paper and board stock. The recognized need for measuring these properties, particularly on a quality control basis, is evidenced by the multidude of instruments and test methods developed during the past two decades. Unfortunately, a multitude of conflicting opinions regarding their reliability also developed.

The FPBAA Printability Research Program was initiated at Lehigh University in an attempt to resolve the printability evaluation problem for paperboard. The approach taken in this fundamental investigation was to determine the printing properties of the stocks in the laboratory and to use these results for rating currently available empirical tests for smoothness and absorbency.

The first group of stocks studied consisted of seven widely different types of paperboard along with four coated papers. The results of the comprehensive work on this "survey" series, described previously (*1*), mainly clarified why there were so many conflicting opinions regarding the usefulness of the tests. It was found generally that tests which work well for coated paper may not be applicable to coated board let alone to

uncoated board, and vice versa. In addition, the ink and printing conditions used affected the relative results, particularly for gloss holdout and print uniformity.

The broad implication of this latter finding is that "the printability of paperboard," for instance, is an erroneous expression which might better be replaced by the term "printability of an ink-board-press combination." Furthermore, since empirical test measurements cannot be presently related to the effects of ink and press, the most reliable method for evaluating printability will be provided by a good control press test.

However, although no empirical test was found to be applicable to every type of stock, it was recognized that the important value of quality control tests is to compare properties within a class rather than between classes. Therefore, a second series consisting of 18 white patent coated boards was studied next. The presentation of the work on this series is divided into the following sections: (1) experimental work, (2) evaluation of smoothness tests, (3) evaluation of absorbency tests, and (4) standardization of tests for quality control.

EXPERIMENTAL WORK

The work on the white patent coated boards followed an approach similar to that for the survey series. Solid prints were made with four letterpress inks on a proof press under carefully controlled conditions. Ink transfer and print quality were measured, and the printing results for smoothness and absorbency were used to determine statistically the correlations of the empirical test measurements. This section describes the experimental details.

White Patent Coated Samples. White patent coated board was selected for the second series because it is the most commonly used in the carton industry. (This type of board is not coated as its name implies.) Ten cooperating mills supplied a total of 18 samples, most of which were boards regularly produced for flat ink work and cut from the center of a single roll. In addition, samples with different finishes, from different positions on the machine, and from several lots were secured. The boards, numbered in the order in which they arrived, are listed in Table IA together with their caliper, compressibility, and base gloss.

Printing Inks. Since the work on the survey series illustrated clearly that the relative printing properties of the stocks depended on the properties of the ink used, it was considered essential to print the white patent coated series with several inks. Four oil-based letterpress inks were selected on the basis that they showed wide gloss holdout differences on experimental white patent boards which were known to have varying absorbencies. The properties of these inks are summarized in Table IB.

The two black inks were testing inks supplied by two ink companies. The blue and the red inks were commercial carton inks submitted by two FPBAA member companies.

Printing Techniques. The printing experiments were carried out on a hand-driven Vandercook no. 4 proof press under the carefully controlled conditions listed in Table IC. Printing pressure and speed were measured respectively with the Huck base and the microswitch-clock arrangement which is an integral part of the controlled printing set-up at Lehigh (*2*). Ink film thickness was measured by weighing the impression plate before and after each printing. The stocks were cut into 4 $^1/_4$ by 11-in. sheets for printing with the grain short and parallel to the axis of the printing cylinder. To insure adequate sampling, about 30 prints were made with the two black inks over the ink film thickness range listed. Only three or four prints were made with the two colored inks, all above the lower practical limit.

Ink Transfer Measurements. Ink transfer from the impression plate to the boards was measured carefully to determine the transfer characteristics of the stocks and also to compare print quality at known ink film thicknesses. As indicated previously, complete transfer measurements were made only with the two black inks.

The transfer data were expressed graphically with the two usual types of plots illustrated in Fig. 1: (a) per cent transfer to the boards versus ink film thickness on the plate, showing that per cent transfer increases at first, reaches a maximum, and then decreases; and

Table I. Boards, Inks, and Printing Conditions

A. White Patent Coated Board Samples

Code	*Coded source*	*Type*	*Caliper, mils*	*Compressibility at 750 p.s.i., %*	*Base gloss 70°, %*
WP-1	Mill no. 1	Regular	16.9	8.4	32.9
WP-2	Mill no. 2	Regular	17.2	7.9	28.9
WP-3	Mill no. 3	Regular	16.9	12.1	32.5
WP-4	Mill no. 4	Regular	16.5	8.5	30.7
WP-5	Mill no. 5	Regular	16.1	9.0	30.3
WP-6	Mill no. 6	Regular	16.8	12.3	30.1
WP-7-F2	Mill no. 7	Finish no. 2	19.8	9.4	26.7
WP-8-F3	Mill no. 7	Finish no. 3	22.5	8.0	26.4
WP-9	Mill no. 8	Regular	18.0	11.9	27.7
WP-10-R	Mill no. 9	Regular	16.2	9.7	28.9
WP-11-no. 1	Mill no. 10	Regular, lot no. 1	17.5	8.1	27.0
WP-12-no. 2	Mill no. 10	Regular, lot, no. 2	19.9	9.9	30.3
WP-13-M	Mill no. 9	Cut from middle	20.9	12.4	34.4
WP-14-F	Mill no. 9	Cut from front	20.0	11.7	35.9
WP-15-B	Mill no. 9	Cut from back	21.4	12.3	31.0
WP-16-LF	Mill no. 9	Less finish	20.9	12.3	30.6
WP-17-MF	Mill no. 9	More finish	21.2	12.1	32.9
WP-18-no. 3	Mill no. 10	Regular, lot no. 3	17.8	9.5	30.2

B. Printing Inks

Code	*Color*	*Viscosity 73°F., poises*	*Drying time on WP-stock, hr.*
No. 3	Black	90	5
No. 4	Black	66	4
No. 5	Light blue	75	1
No. 6	Transp. red	150	3

C. Printing Techniques

Printing pressure	100 lb. per linear in. (*ca.* 5 mils impression)
Printing speed	185 f.p.m.
Room temperature	73°F. ± 1°
Relative humidity	50 ± 2%
Impression plate	Magnesium, solid face, letterpress
Plate dimensions	$3^1/_2 \times 6 \times {}^1/_{16}$ in.
Ink film thickness	0.5 to 30 mu on plate

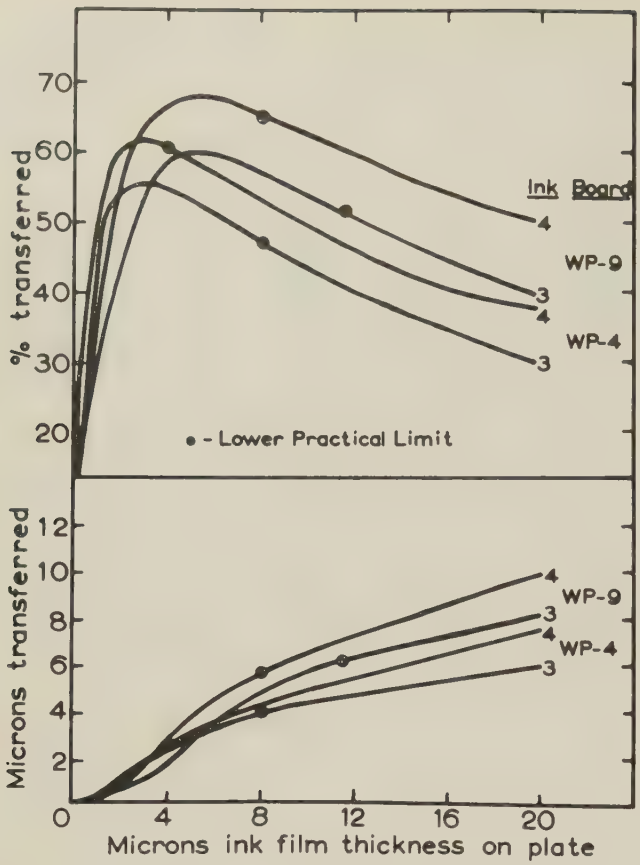

Fig. 1. Extremes in transfer characteristics of the WP series

(b) thickness of ink transferred to the boards versus ink film thickness on the plate, showing a continuous increase.

Note in Fig. 1 that ink no. 4 transferred more to a particular board and required less ink to produce full coverage than did ink no. 3. The two boards, WP-4 and 9, were selected for these plots because they represented the extremes in transfer in the practical ink film thickness range. The other 16 boards gave results which fell between these two curves.

Several techniques have been proposed for describing transfer characteristics numerically (3–6). For the purposes of the present correlation study, the most important characteristic is transfer in the thin ink film area, which is recognized as being dependent on fraction contact and therefore related to printing smoothness. The transfer parameter selected was k, the Lehigh printing smoothness constant (*3*), calculated from low ink film transfer results.

Print Gloss Measurements. Although print quality comprises many factors such as color, gloss, and uniformity, the most important of these for the present study is gloss, which was used as the primary basis for judging the effectiveness of absorbency tests. The print gloss measurements were made with the Vanceometer, which is essentially a 70° gloss meter.

Table II. Smoothness and Absorbency Measurements on the White Patent Coated Boards

Test	*Reference*	*Samples*	*Brief description*
Bekk	TAPPI (*7*)	10	Time for 10 ml. air to flow between sample and head.
Gurley H-P-S	Gurley (*8*)	10	Time for 10 ml. air flow; pressures of 3, 24, 54, and 84 p.s.i.
Sheffield	Wilt (*9*)	10 × 6[a]	Rate of air flow at 1.5 p.s.i. over two annular lands each 0.015 in. wide.
Bendtsen	Bendtsen (*10*)	10 × 6[a]	Rate of air flow at 0.25 p.s.i. over one land 0.006 in. wide; head weights of 1 and 5 kg./sq. cm.
Chapman	Obenshain (*11*)	5	Per cent contact against glass prism; offset blanket and tympan backings; pressures of 150, 500, and 900 p.s.i.
Brush	Roehr (*12*)	5	Per cent of surface below depths of 225 microinch machine and across, 150 microinch across.
Scheid	Scheid (*13*)	2	Angle at which resolution of surface irregularities sharply decreases.
Photo	Ragan (*14*)	1	Visual rating by 10 observers of surface photomicrograph 23×.
Vanceometer	Vallandigham (*15*)	4	Three oils; 5 drops placed on top of steel roller; gloss readings from 5 sec. to equilibrium.
Vanceometer	Long (*16*)	4	Special CCA blue ink instead of oil.
Vanceometer	Zentner (*17*)	4	Dicalite dispersion used.
Hull wipe	Hull (*18*)	10	Black ink, removed immediately.
Hull wipe	Hull (*18*)	10	Red ink, removed after 60 sec.
K and N	TAPPI (*19*)	10	Purple ink, removed after 2 min.
Oil drop	Long (*16*)	10	Two drops of 55 poise oil placed on sample inclined at 45°; time for disappearance of gloss recorded.
Penetration Volumeter	Tollenaar (*20*)	4	Rate of oil flow into sample measured by air displacement with 6.5 poise mineral oil, 0.0024 sq. cm. capillary tube.
Porosity	Wilt (*9*)	10 × 6[a]	Rate of air flow through the sheet.

[a] Six measurements made on each of 10 samples.

Table III. Smoothness Results on the White Patent Coated Boards

Transfer constant k: Ink no. 3 W P	Ink no. 3 mu^{-1}	Ink no. 4 W P	Ink no. 4 mu^{-1}	Sheffield W P	Sheffield cc./min. × 10^{-2}	Bendtsen 1 kg./sq. cm. W P	Bendtsen 1 kg./sq. cm. cc./min.	Bendtsen 5 kg./sq. cm. W P	Bendtsen 5 kg./sq. cm. cc./min.
4	0.510	4	0.591	10-R	92	5	89	5	32.7
6	0.486	6	0.580	6	95	10-R	100	10-R	39.5
3	0.460	3	0.551	5	96	4	111	11-no. 1	41.5
18-no. 3	0.459	18-no. 3	0.530	4	120	6	119	4	45.0
14-F	0.455	14-F	0.525	18-no. 3	126	11-no. 1	126	6	46.4
10-R	0.454	10-R	0.520	11-no. 1	128	16-LF	136	13-M	46.4
13-M	0.450	13-M	0.520	16-LF	130	17-MF	140	14-F	46.9
17-MF	0.430	17-MF	0.512	1	135	13-M	165	17-MF	47.2
12-no. 2	0.429	1	0.508	3	139	12-no. 2	178	16-LF	48.6
1	0.418	5	0.506	17-MF	158	14-F	186	12-no. 2	51.3
5	0.417	15-B	0.487	14-F	160	18-no. 3	188	15-B	56.4
15-B	0.417	12-no. 2	0.486	15-B	161	15-B	190	3	61.8
16-LF	0.403	2	0.486	12-no. 2	166	1	196	18-no. 3	63.6
11-no. 1	0.402	11-no. 1	0.481	13-M	176	3	203	1	68.4
2	0.398	16-LF	0.478	2	185	8-F3	267	8-F3	73.2
9	0.393	9	0.472	7-F2	188	2	280	7-F2	76.7
7-F2	0.365	7-F2	0.452	8-F3	205	7-F2	281	2	81.0
8-F3	0.353	8-F3	0.405	9	212	9	298	9	112.6

Bekk W P	Bekk sec.	Gurley 3 p.s.i. W P	Gurley 3 p.s.i. sec.	Gurley 24 p.s.i. W P	Gurley 24 p.s.i. sec.	Gurley 54 p.s.i. W P	Gurley 54 p.s.i. sec.	Gurley 81 p.s.i. W P	Gurley 81 p.s.i. sec.
11-no. 1	23.3	5	34.0	5	68.0	5	111.7	5	173
1	18.8	4	30.0	4	48.5	4	84.9	4	141
18-no. 3	17.5	1	28.6	14-F	41.9	14-F	84.7	3	136
5	16.0	12-no. 2	28.6	3	41.4	18-no. 3	80.9	11-no. 1	132
4	15.6	14-F	26.0	12-no. 2	38.8	11-no. 1	78.6	12-no. 2	130
7-F2	15.5	10-R	25.0	1	38.3	3	78.1	18-no. 3	130
14-F	14.8	11-no. 1	24.6	10-R	37.0	13-M	77.4	1	130
10-R	14.6	17-MF	22.7	18-no. 3	37.2	12-no. 2	75.2	14-F	123
12-no. 2	14.0	3	22.6	8-F3	36.6	17-MF	73.1	10-R	119
3	13.6	8-F3	21.3	13-M	35.1	1	68.6	7-F2	114
13-M	13.5	18-no. 3	21.1	11-no. 1	35.6	10-R	65.4	17-MF	108
8-F3	13.4	7-F2	20.0	7-F2	34.6	8-F3	61.1	8-F3	107
6	13.0	13-M	19.1	17-MF	34.0	15-B	61.8	13-M	103
15-B	12.3	15-B	19.0	15-B	31.3	7-F2	57.5	6	100
17-MF	12.0	6	17.3	2	27.7	2	55.3	2	96
2	10.8	10-LF	16.5	6	27.7	16-LF	54.1	15-B	89
10-LF	10.0	2	15.3	16-LF	27.1	6	52.4	16-LF	78
9	9.5	9	14.7	9	25.3	9	39.7	9	71

k: Ink no. 3 W P	Ink no. 3 mu^{-1}	Brush roughness 225 microinch Machine W P	Machine %	225 microinch Across W P	Across %	150 microinch Across W P	Across %	Scheid degrees W P	°	Photographs visual rating W P	Rank
4	0.510	4	0.8	14-F	1.0	13-M	3.1	4	8.0	4	1.0
6	0.486	13-M	0.8	12-no. 2	1.4	14-F	3.2	14-F	8.2	5	2.4
3	0.460	14-F	0.8	13-M	1.4	4	3.6	18	8.8	14-F	3.0
18-no. 3	0.459	11-no. 1	0.9	18-no. 3	1.45	18-no. 3	4.0	10-R	8.8	18-no. 3	4.4
14-F	0.455	3	0.9	4	1.5	12-no. 2	4.2	3	9.2	3	5.5
10-R	0.454	12-no. 2	1.0	11-no. 1	1.5	11-no. 1	4.3	5	9.2	17-MF	7.4
13-M	0.450	5	1.1	17-MF	1.8	16-LF	4.5	6	9.2	12-no. 2	7.8
17-MF	0.430	10-R	1.3	3	1.8	17-MF	4.7	8-F no.	9.2	6	8.0
12-no. 2	0.429	17-MF	1.3	5	1.9	10-R	4.8	9	9.5	10-R	8.0
1	0.418	15-B	1.4	16-LF	2.1	5	5.0	11-no. 1	9.8	13-M	8.4
5	0.417	16-LF	1.4	6	2.25	15-B	5.2	12-no. 2	9.8	1	11.3
15-B	0.417	6	1.6	1	2.3	3	5.4	15-B	9.8	15-B	11.4
16-LF	0.403	1	1.6	15-B	2.4	1	5.5	10-R	10.0	11-no. 1	12.4
11-no. 1	0.402	7-F2	1.7	7-F2	2.4	6	5.9	13-M	10.0	16-LF	12.8
2	0.398	9	2.1	10-R	3.1	7-F2	6.1	16-LF	10.2	8-F3	14.7
9	0.393	2	2.15	9	3.3	9	6.2	17-MF	10.5	2	15.6
7-F2	0.365	8-F3	2.3	8-F3	3.6	2	6.4	2-M	11.0	7-F2	17.0
8	0.353			2	3.9	8-F3	7.0	7-F2	11.0	9	18.0

Chapman: Tympan backing 150 p.s.i. W P	150 p.s.i. %	500 p.s.i. W P	500 p.s.i. %	900 p.s.i. W P	900 p.s.i. %	Offset blanket backing 150 p.s.i. W P	150 p.s.i. %	500 p.s.i. W P	500 p.s.i. %	900 p.s.i. W P	900 p.s.i. %
6	9.0	13-M	20.1	13-M	28.5	14-F	13.3	14-F	27.6	14-F	38.0
13-M	8.8	6	19.3	1	27.6	17-MF	12.6	16-LF	24.3	18-no. 3	33.6
17-MF	8.6	1	19.2	6	26.7	16-LF	11.1	17-MF	23.6	16-LF	33.5
18-no. 3	8.4	3	18.3	14-F	26.6	13-M	10.8	18-no. 3	23.3	17-MF	33.2
1	8.1	14-F	18.0	3	26.5	6	10.6	6	22.2	13-M	32.0
15-B	8.1	17-MF	17.8	16-LF	25.7	18-no. 3	10.5	13-M	21.9	1	30.9
10-R	7.9	10-R	17.3	17-MF	25.6	1	9.3	1	21.6	3	30.0
16-LF	7.9	15-B	17.2	15-B	25.3	3	8.9	3	20.8	6	29.8
14-F	7.7	5	17.1	5	24.8	5	8.9	5	20.1	15-B	29.4
3	7.4	18-no. 3	16.3	10-R	24.0	11-no. 1	8.9	8-F3	19.9	12-no. 2	29.3
5	7.4	8-F3	16.0	8-F3	23.8	15-B	8.7	15-B	19.4	5	28.3
11-no. 1	6.9	11-no. 1	15.8	18-no. 3	23.5	8-F3	8.5	12-no. 2	19.4	8-F3	28.0
8-F3	6.7	16-LF	15.7	11-no. 1	22.8	4	7.8	11-no. 1	18.4	11-no. 1	27.3
4	6.2	4	14.9	4	22.3	7-F2	7.8	10-R	18.2	10-R	25.6
7-F2	6.2	2	14.5	2	21.5	10-R	7.6	4	17.4	4	25.5
2	6.1	7-F2	14.2	7-F2	20.9	2	6.8	7-F2	17.2	9	25.1
12-no. 2	6.0	12-no. 2	13.9	9	20.6	12-no. 2	6.5	9	16.5	7-F2	24.5
9	5.7	9	13.7	12-no. 2	20.5	9	6.4	2	15.4	2	22.8

Physical Measurements. Table II lists the smoothness and absorbency test measurements made on the boards. Also listed are the developer with the corresponding reference, the number of specimens on which measurements were made, and a brief description of the test along with variations in technique used.

Correlation Techniques. The correlations between the printing and physical properties of the boards were determined according to established statistical methods. The degree of correlation was expressed by r, the product moment correlation coefficient calculated according to Brownlee (*21*), using numerical values for the printing results and the corresponding test measurement.

EVALUATION OF SMOOTHNESS TESTS

Smoothness, which has been previously defined as the approximation of the surface to an optical flat under the stated pressure conditions, is a very important property of board from a practical standpoint because it affects the ease of ink transfer from the printing plate as well as the uniformity of the resulting print. Since the printing smoothness of the white patent coated boards was determined at five mils impression, smoothness should be defined here as the ability of the board to contact the printing plate at 5 mils impression. It is recognized that lower or higher pressures may produce different relative results. The impression used was selected because a survey of a few plants indicated that 5 mils is a representative minimum pressure for commercial printing.

The first two columns in Table III list the k values for the boards, calculated from ink transfer measurements below adequate coverage. Note that both inks rated the boards in almost the same order; the only exceptions were that boards 12 and 16 were rated as being relatively rougher by ink no. 4 than by ink no. 3. A possible reason for this discrepancy is that the two inks, which differed in viscosity, reacted differently toward the surface inhomogeneities of the boards. Note also in Table III that the k values for ink no. 4 were always higher than those for ink no. 3. As was mentioned previously, ink no. 4 had the higher transfer characteristics and also required the less ink to produce fully covered prints; hence it produced the higher k values.

The smoothness of the boards was also rated according to 20 empirical test measurements, using four air flow instruments, one optical, and three surface analysis tests. Examination of the results in Table III shows that no two methods rated the stocks in the same order. There were, in fact, many wide discrepancies. For example, board 6 was rated as one of the smoothest boards by printing, Sheffield, Bendtsen, and Chapman with the tympan backing, but much rougher by the other tests; board 5 was rated at or near the top by all four air flow instruments and the photomicrographs, but in the middle by the other tests. Most tests agreed, however, in rating boards 2, 7, 8, and 9 as the roughest.

Special attention should be paid to the boards which were supplied in different finishes, from different positions on the rolls, and from different lots. All tests except Scheid agreed that there was little significant difference between board 7 (finish no. 2) and board 8 (finish no. 3), but there was less agreement regarding the other pair of boards of this type: 16 (less finish) and 17 (more finish). Board 17 was rated as the definitely smoother of the two by printing, Gurley, the photomicrographs, while the other measurements rated them very close together.

There was also fairly general agreement that the board cut from the front of the roll (14-F) was smoother than that from the middle (13-M) than that from the back (15-B). On the other hand, there was poor agreement about the boards from the three lots. Printing, Chapman with the offset blanket, and the photomacrographs agreed in their rating 18 (lot no. 3) smoother than 12 (lot no. 2) than 11 (lot no. 1); Bendtsen also rated the boards as being different but in a reversed order, while the other tests rated two and sometimes all three boards equivalent in smoothness.

Table IV lists the values for the correlation coefficient r, which is the numerical expression for the degree of correlation of the empirical measurements with the printing primary standard k. This table shows that none of the smoothness tests produced correlation coefficients of 0.90, which is regarded by some statisticians as the minimum value required for a test to be considered reasonably reliable. The surface

Table IV. Correlation Coefficients for Smoothness Tests

Test technique vs.	*Transfer constant k* — *Ink no. 3* r	*Ink no. 4* r	*Av.* r
Bekk	0.128	0.128	0.128
Gurley H-P-S,			
3 p.s.i.	0.185	0.255	0.220
24 p.s.i.	0.317	0.265	0.296
54 p.s.i.	0.368	0.396	0.382
81 p.s.i.	0.403	0.389	0.396
Sheffield	−0.631	−0.639	−0.635[b]
Bendtsen,			
1 kg./sq. cm.	−0.614	−0.589	−0.601[b]
5 kg./sq. cm.	−0.498	−0.436	−0.467
Chapman			
Tympan backing,			
150 p.s.i.	0.406	0.408	0.407
500 p.s.i.	0.363	0.370	0.366
900 p.s.i.	0.348	0.369	0.358
Offset blanket,			
150 p.s.i.	0.302	0.285	0.293
500 p.s.i.	0.295	0.281	0.289
900 p.s.i.	0.289	0.279	0.284
Brush roughness,			
225 mu A	−0.644	−0.591	−0.618[b]
225 mu M	−0.640	−0.581	−0.610[b]
150 mu A	−0.602	−0.497	−0.550
Scheid	−0.630	−0.607	−0.618[b]
Surface photomacrographs	−0.806	−0.736	−0.771[a]

Note: A positive value of r means that the relationship between the empirical test and the printing test is proportional; a negative value means it is inversely proportional. The magnitude of r without respect to sign is the significant value.

[a,b] Surpassed the 99.9 and 99% confidence levels, respectively. For 18 pairs of samples (16 degrees of freedom)

r value of 0.708	indicates a confidence level of 99.9%
0.590	99.0%
0.543	98.0%
0.468	95.0%
0.400	90.0%

Confidence levels are not a measure of reliability. They indicate only the frequency with which values of r as large as those obtained experimentally can arise by chance. For example an r value of 0.590 has a confidence level of 99.0%, indicating that such a value of r could be obtained only one time out of a 100 in the complete absence of any correlation.

photomacrographs produced the highest values, averaging 0.77; Sheffield, Bendtsen, Brush roughness, and Scheid exceeded 0.60; while Bekk, Gurley, and Chapman were considerably lower.

It is interesting that the surface photomacrograph

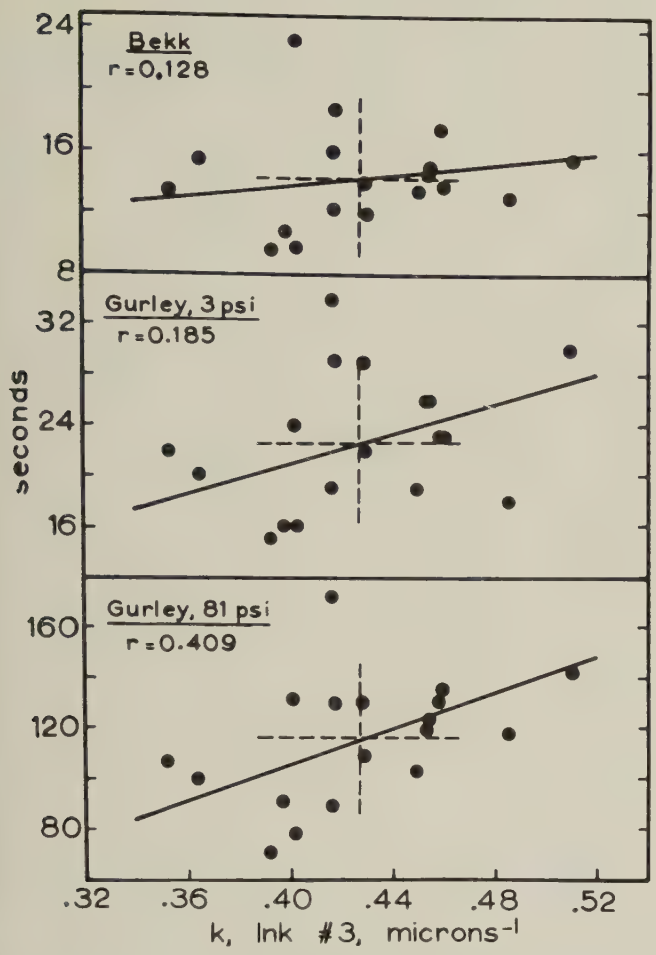

Fig. 2. Air leak smoothness tests versus printing smoothness

test, which is a visual evaluation of "free" smoothness, correlated the best, and that the tests which correlated next best also measure "free" smoothness. It may be concluded from this finding that printing smoothness at low impression pressures is related to free surface smoothness. The 5 mils impression pressure used in the printing experiments was on the low side according to the survey of printing plants. However, successful printing with a minimum of impresion pressure should be the goal sought for in commercial practice.

Despite the fact that the white patent coated boards had compressibilities of the same order of magnitude, nevertheless, differences in compressibility might well explain some of the discrepancies between printing and the free smoothness tests. For example, most of the free smoothness tests definitely rated board 9 as the roughest, but printing rated boards 7 and 8 rougher than 9. The 11.9% compressibility of board 9 compared to the 9.4 and 8.0% of the other two boards may be the reason. Looking at the tests which were made at several pressures, it is rather curious that the correlation of the Gurley increased with pressure while the opposite was the case for Bendtsen and Chapman.

Graphical representation of the relation between the empirical and printing tests follows in Fig. 2 to 5. The solid line through the points is the calculated line of regression, the horizontal dotted line is the mean of the empirical test values, and the vertical dotted line is the mean of the printing transfer constant k values. The correlation coefficient r is reduced from the perfect value of 1.0 when the points are scattered away from the line of regression. Points which fall in either of the quadrants through which the regression line does not pass are particularly harmful.

These plots illustrated that all the tests exhibited a good deal of scatter with a few points falling in the wrong quadrants. Note that the surface photomacrographs exhibited the least amount of scatter with only one print falling in the wrong quadrant.

EVALUATION OF ABSORBENCY TESTS

Although absorbency is a complex process involving ink transfer, rate of setting, and final degree of penetration, its most important end effect from a practical standpoint is final gloss holdout. Therefore, absorbency tests were evaluated primarily for their ability to correlate with print gloss.

In using print gloss as the primary standard, two

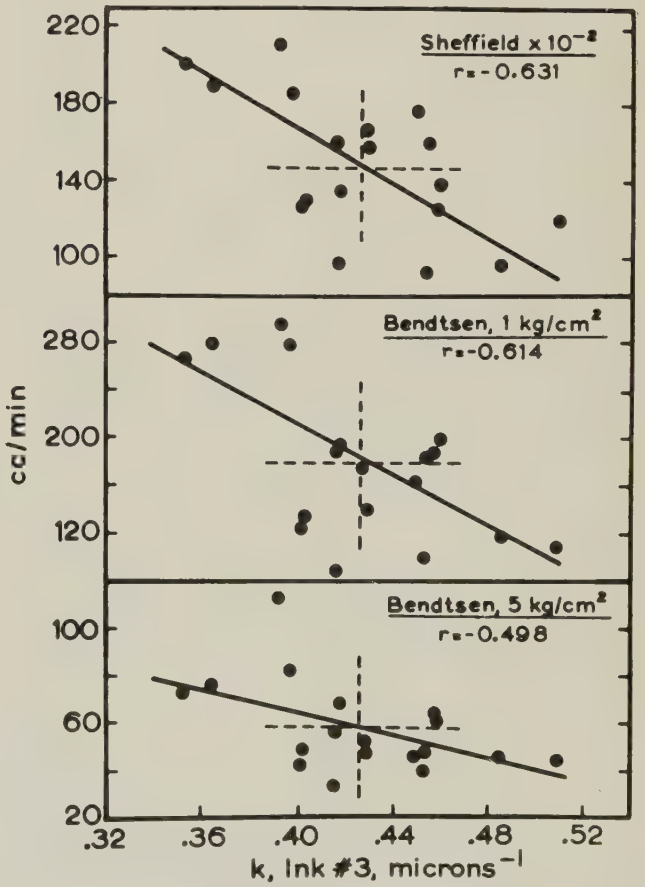

Fig. 3. Rate of air flow smoothness tests versus printing smoothness

problems which had been encountered with the survey series were not evident with the white patent coated series. First, with the previous series, relative gloss holdout was quite dependent on ink film thickness. For example, print gloss decreased and then increased

with ink film thickness on stocks having a very high base gloss, increased and then levelled off on a coated board, but increased continuously within the useful range on most stocks. This situation created several orders in which the stocks could be rated for gloss holdout.

Fortunately, with the white patent coated boards (none of which were coated or varied widely in base gloss), print gloss increased continuously with no tendency for the ranking order to change with increasing ink film thickness. Print gloss at 6 mu of ink on the print was arbitrarily selected for rating gloss holdout.

The second problem encountered previously was that gloss holdout ranking was dependent on the ink used particularly in the case of coated stocks. Again, this situation did not occur with the white patent boards, despite the fact that they were printed with inks varying considerably in viscosity, opacity, and drying time. Although the four inks produced different numerical values for print gloss, which could be correlated apparently with viscosity, they ranked the boards in somewhat similar orders as the data in Table V show. All inks rated board 14-F as having the best gloss holdout and boards 2 and 9 the least. Where changes in

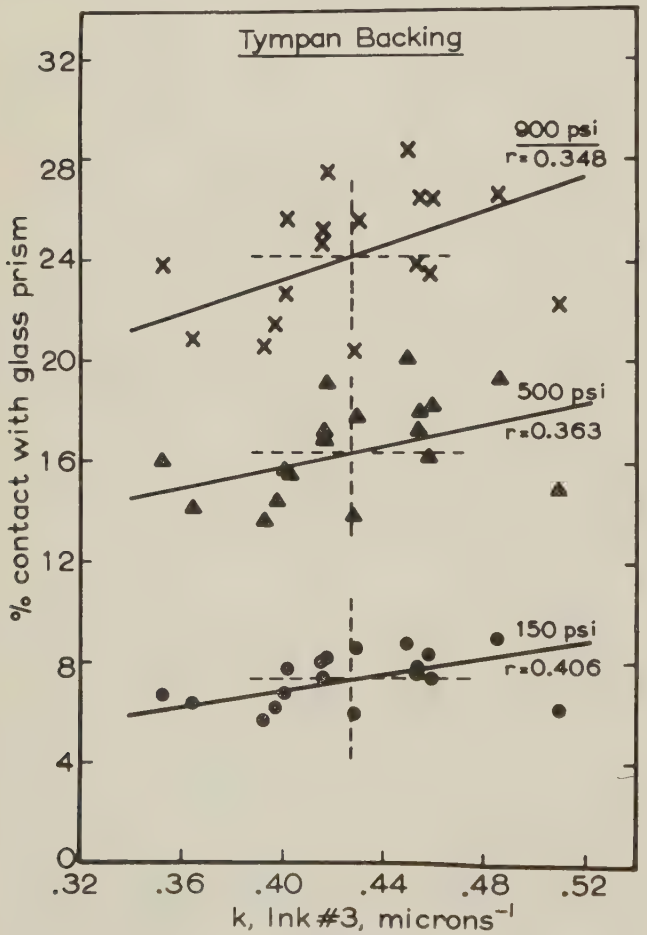

Fig. 4. Chapman smoothness versus printing smoothness

ranking did occur, they were caused by slight differences in the numerical value for gloss.

Note, however, that neither the two black testing inks nor the two commercial colored inks showed up the differences in finish between boards 17 (more finish) and 16 (less finish), whereas board 7 (finish no. 2) always produced prints about 5 units higher in gloss than board 8 (finish no. 3). The four inks generally rated 13 and 15 (cut from the middle and the back) close together but lower in gloss holdout than 14(cut

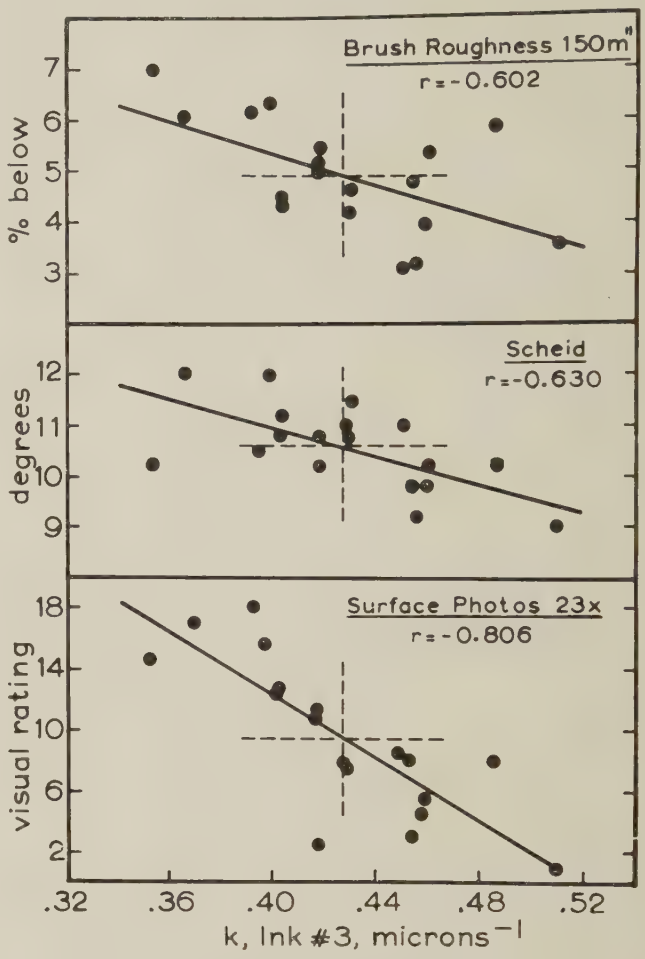

Fig. 5. Surface analysis versus printing smoothness

from the front). Boards 11 and 12 (lots nos. 1 and 2) were also generally rated fairly similar to each other, with 18 (lot no. 3) being much lower in gloss holdout.

That there was a general trend for ink gloss holdout to increase with base gloss of the boards is illustrated in Fig. 6. The correlation coefficient, however, was only 0.640. The trend is nevertheless interesting in

Table V. Print Gloss Measurements on the White Patent Coated Boards

70° Gloss readings with 6 mu ink on print								Composite	
Black ink no. 3		Black ink no. 4		Blue ink no. 5		Red ink no. 6			
W P	Gloss	W P	Gloss	W P	Gloss	W P	Gloss	W P	Rating
14-F	85	14-F	73	14-F	75	14-F	87	14-F	1.0
12-no. 2	79	4	65	17-MF	74	15-B	85	17-MF	3.8
17-MF	78	11-no. 1	62	17-LF	74	13-M	84	16-LF	4.6
16-LF	77	13-M	62	15-B	72	17-MF	84	15-B	5.0
4	76	12-no. 2	59	4	71	16-LF	83	13-M	5.2
13-M	76	17-MF	56	3	70	12-no. 2	82	4	5.4
15-B	76	16-LF	55	11-no. 1	69	11-no. 1	81	12-no. 2	5.5
11-no. 1	74	15-B	54	13-M	69	3	80	11-no. 1	6.5
5	72	3	52	12-no. 2	68	4	80	3	8.4
3	68	1	51	5	67	5	78	5	10.0
10-R	68	5	49	10-R	63	18-no. 3	76	18-no. 3	12.0
7-F2	66	18-no. 3	48	18-no. 3	63	7-F2	74	1	12.5
1	65	6	47	7-F2	62	1	73	10-R	12.6
18-no. 3	61	7-FS	45	8-F3	57	10-R	70	7-F2	13.1
6	60	10-R	45	1	53	8-F3	69	8-F3	14.9
8-F3	60	8-F3	40	6	42	6	66	6	15.2
2	58	2	38	2	42	2	63	2	16.9
9	56	9	33	9	40	9	62	9	18.0

Table VI. Absorbency Test Results on the White Patent Coated Boards

Board W P	Vanceometer, % — Light oil LCB-5 — 5 sec.	20 sec.	60 sec.	Heavy oil NCS-12 — 5 sec.	20 sec.	60 sec.	Very heavy oil LCY-4 — 5 sec.	20 sec.	60 sec.
14-F	87.5	77	46	92.5	77.5	51.5	97.5	92.5	76.5
17-MF	79	53	41	90.5	72.5	46	97	92.5	72
16-LF	73.5	45.5	36	90.5	68.5	48	94	85.5	58.5
15-B	77	45.5	36.5	93.5	76	46.5	96.5	88.5	59
13-M	77	50.5	40.5	92.5	72	44	95.5	92.5	70
4	80	56	38	92	82	54	93	91	74
12-no. 2	76	46.5	33.5	86.5	64.5	41	94.5	90.5	70
11-no. 1	82	55.5	37.5	90.5	77.5	47	96.5	93.5	78.5
3	62	44	41	88	54	47	90	76	50
5	78	43	35	92	74	38	94	92	69
18-no. 3	64.6	39	35	79.6	44	33.5	94.3	82.3	46.5
1	70	46	40	76	49	40	88	72	49
10-R	44	37	35	77	42	33	90	78	46
7-F2	60	35	31	46	41	31	94	89	63
8-F3	65	44	38	80	50	35	94	87	44
6	44	37	35	50	39	35	72	46	40
2	38	34	31	50	36	34	62	41	36
9	44	36	34	72	34	31	82	48	38

Board W P	CCA blue ink — 2 min.	10 min.	Dic.[a] Av.[b]	Wipe tests, R%(R₀ = 100) — Hull black	Hull red	K + N	Oil drop, sec.	Pen. vol., $K_1 \times 10^{4}$[b]	Porosity, cc. × 10^{-2} min.
14-F	95	91.5	73	33.9	39.8	77.7	165	4.7	12.1
17-MF	90.5	80.5	66.1	28.6	36.7	74.0	130	9.5	14.2
16-LF	94.5	91.5	63.3	28.0	34.2	70.4	139	11.9	19.8
15-B	95.5	92	65.3	26.0	33.4	69.5	136	9.4	17.8
13-M	95.5	91.5	68	30.0	37.0	74.3	131	10.4	14.9
4	93	86	82	25.9	37.3	71.7	194	10.5	14.6
12-no. 2	92	88.6	79.4	26.3	33.5	68.8	152	9.5	9.9
11-no. 1	94.5	93	89	26.0	37.2	71.4	229	3.5	8.6
3	95	86	50.4	26.2	35.3	69.8	93	21.6	20.7
5	96	86	87.7	24.4	34.0	65.8	168	8.0	11.6
18-no. 3	81.5	74	55.1	23.2	31.7	67.9	113	12.2	15.1
1	92	73	49.8	23.6	29.3	63.0	104	20.6	13.7
10-R	96	89	54.2	19.2	27.0	61.1	108	14.5	20.3
7-F2	93	75	47.3	22.9	29.3	64.5	128	14.0	13.5
8-F3	91	76	53.8	18.9	26.4	64.1	144	12.3	14.3
6	66	38	39	20.4	23.1	58.7	67	37.6	30.8
2	70	38	38.4	20.0	25.4	52.7	61	13.3	31.2
9	84	46	44	17.4	22.7	53.8	65	30.7	23.1

[a] Dicalite dispersion, average of readings at 0, 10, 20, and 30 sec.
[b] Paper constant related to the average size and number of pores.

view of the opaque nature of the inks used and the fairly narrow range in base gloss of the board samples.

The absorbency test measurements are summarized in Table VI, where the boards are listed in order of decreasing composite gloss holdout. With the exception of a few controversial cases, most test values tended to line up the boards reasonably similar to their gloss holdout ranking.

Two particularly controversial boards are 11 and 3. Board 11 was rated the least absorbent of all boards by most of the tests, particularly by those which measure either surface porosity or setting time: early Vanceometer readings with oil, with the dicalite dispersion, oil drop time, penetration by volumetry, and porosity by air flow. These tests, on the other hand, rated board 3 much more absorbent than 11. Yet both boards produced prints very similar in gloss holdout with the two commercial colored inks; the two opaque black testing inks did tend to rate board 11 higher in gloss holdout than 3 but certainly not as being the best of all the boards. The ink wipe tests, however, agreed with the two colored inks in rating the two boards close together.

A similar situation exists with boards 7 and 8 (finish no. 2 and 3). The setting time tests rated board 8 as less absorbent than 7, while the ink wipe tests rated them in the opposite direction as did their gloss holdout with all four inks.

These cases serve to illustrate that final degree of penetration may not necessarily be a function of rate of penetration and that the behavior of porous surfaces toward oil may be quite different than their behavior toward pigmented systems such as printing inks are.

The values for the correlation coefficient r are listed in Table VIII, where it can be seen that several tests closely approached the minimum r value of 0.90 required for the test to be considered reliable. Correlation coefficients of at least 0.89 were obtained with the three ink wipe tests (Hull black, Hull red, and K and N) and with the Vanceometer measurements at 20 seconds with heavy oil NCS-12. The Vanceometer

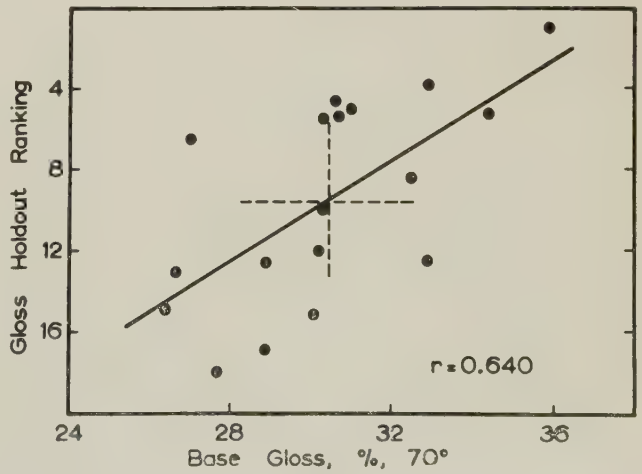

Fig. 6. Print gloss as a function of base gloss of the boards

at other times and with other oils and dispersions produced lower correlations as did the Penetration Volumeter, oil drop, and porosity measurements.

Even the least effective absorbency tests generally correlated with gloss holdout better than the smoothness tests did with printing smoothness. Representative correlations are illustrated graphically in Figs. 7 to 9.

Table VII. Correlation Coefficients for Absorbency Tests

	Gloss holdout				
Test technique vs.	*Ink 3 (black)* r	*Ink 4 (black)* r	*Ink 5 (blue)* r	*Ink 6 (red)* r	*Av.* r
Vanceometer					
Light oil,					
5 sec.	0.846	0.824	0.838	0.899	0.852[a]
20 sec.	0.678	0.726	0.569	0.667	0.660[b]
1 min.	0.462	0.657	0.486	0.518	0.531
Heavy oil,					
5 sec.	0.722	0.636	0.829	0.771	0.740[a]
20 sec.	0.942	0.925	0.822	0.905	0.899[a]
1 min.	0.878	0.889	0.795	0.870	0.858[a]
Very heavy oil,					
5 sec.	0.727	0.571	0.845	0.784	0.731[a]
20 sec.	0.800	0.728	0.917	0.833	0.820[a]
1 min.	0.890	0.869	0.772	0.839	0.877[a]
2 min.	0.831	0.757	0.675	0.784	0.762[a]
CCA blue ink					
2 min.	0.615	0.483	0.766	0.672	0.634[b]
10 min.	0.776	0.451	0.742	0.836	0.701[b]
Dicalite dispersion	0.747	0.716	0.724	0.709	0.724[a]
Hull black wipe, *R* (*Ro* = 100)	0.890	0.880	0.880	0.921	0.893[a]
Hull red wipe, (*Ro* = 100)	0.875	0.880	0.892	0.912	0.890[a]
K and N ink wipe, (*Ro* = 100)	0.860	0.835	0.920	0.962	0.894[a]
Oil drop time	0.690	0.690	0.625	0.664	0.667[b]
Penetration volumeter	−0.663	−0.618	−0.750	−0.673	−0.686[b]
Porosity	−0.597	−0.573	−0.684	− 0.661	−0.629[b]

[a] Surpassed the 99.9% confidence level (*r* value of 0.708).
[b] Surpassed the 99.0% confidence level (*r* value of 0.590).

STANDARDIZATION OF TESTS FOR QUALITY CONTROL

The prime requisites for quality control tests for printability are that they be simple and rapid to perform without requiring highly skilled personnel, produce numerical values free from human error, and correlate well with actual printing results. Although it is generally recognized that a press test provides the best opportunity for reliability, most press tests have a major drawback in their inherent lack of speed. On the other hand, many empirical type tests have been developed which possess the requisites of speed and simplicity.

Of the many empirical test measurements performed on the boards, a standard technique existed for only one test, the Bekk smoothness test (TAPPI T 479 sm-48), although a routine control test was available for the K and N ink test (TAPPI RC-19). All other tests were in two categories: tests published by the developer, and private company or otherwise unpublished tests still under development. In using these tests, the instructions as written were followed carefully.

After the correlation of the various empirical tests with printing results was established for the white patent coated boards, the more reliable tests were reexamined from an operational standpoint to determine their possible application as routine tests, and some efforts were made to set up standard procedures for using them. Throughout the following discussion, the reader must continuously bear in mind the sampling problem which paperboard presents because of its lack of homogeneity from sheet to sheet as well as within a sheet.

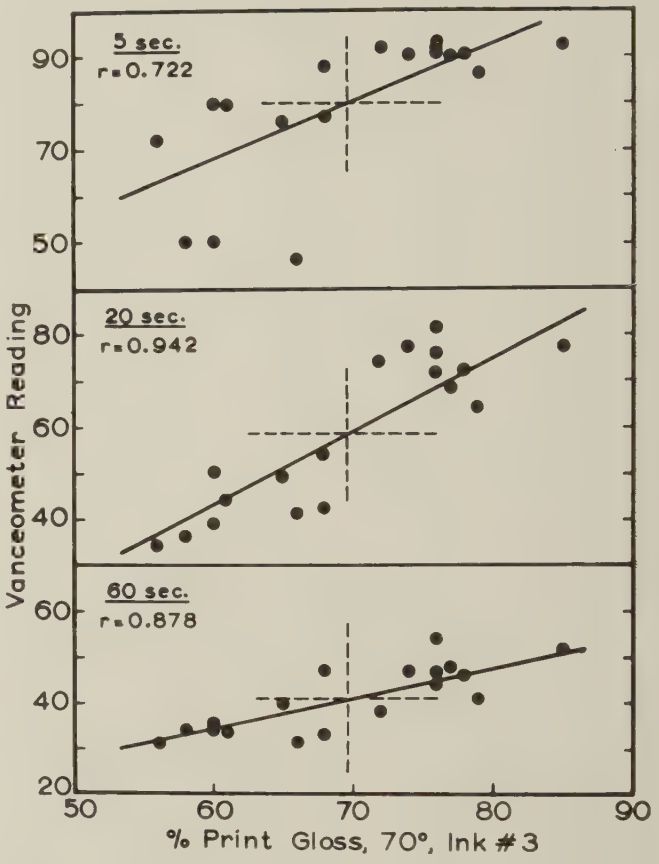

Fig. 7. Vanceometer with heavy oil versus gloss holdout

Smoothness Tests

Based on the correlation coefficients, it was found that surface photomacrographs, Scheid, Brush roughness, and the rate-of-air-flow instruments (Sheffield and Bendtsen) were the best tests for evaluating the smoothness of white patent coated paperboard. It is to be remembered, however, none of these tests measured up to the desired level of reliability in so far as the letterpress printing of solids is concerned.

Surface Photomacrographs. The surface photomacrographs were taken with a magnification of 23× using the Polaroid camera technique developed by Ragan (*14*). In order to show surface fiber configuration, the oblique illumination was across the grain. A presurfacing recommended for uncoated stocks consisted of wiping on a thin alcohol suspension of titanium pigment. It

was found that the alcohol did not affect the lay of the fibers and that the small amount of titanium made the fibers more distinct so that they photographed distinctly. The camera equipment is available from the Erdco Engineering Co., Addison, Ill.

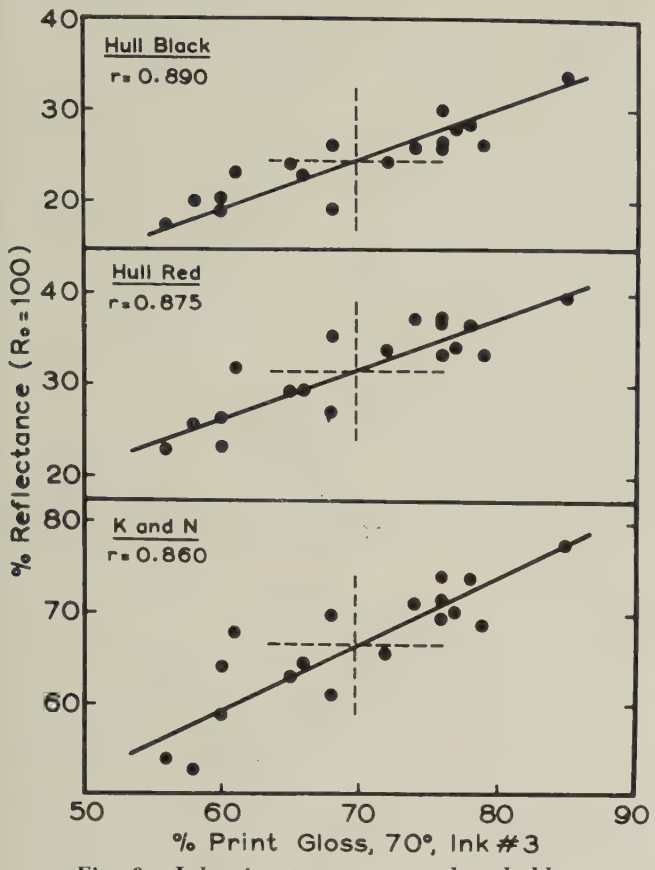

Fig. 8. Ink wipe tests versus gloss holdout

Since the Polaroid process produces a finished print in 1 min., this technique possesses the requisites of speed and ease of operation in addition to fair correlation with the printing results obtained at Lehigh. Ragan had found that the technique is more reliable for halftone printing and gravure solids, than for letterpress and offset solids.

The major failing of the technique is that it does not produce numerical values free from human error. For the present correlation study, numerical values were obtained by having ten observers rank the photographs. The magnification having been 23×, the 3 by 4 in. prints represented less than 0.5 sq. in. of actual board surface. Note from Fig. 10 that the surface structures of the boards were plainly evident, but note also the nonuniformity even within the small area illustrated.

For quality control, it is suggested that a set of standard photos could be compiled and numbered, let us say, from one to five. The test sample could then be rated by comparing its photomacrograph with the standards.

Despite their failure to produce numerical results free from human judgment, the photomacrographs have a major advantage in that they reveal the types and distributions of topographic inhomogeneities on the sample surface. For example, Fig. 10 illustrates the differences in surface contour between the smoothest and the roughest of the white patent coated boards as determined from the printing experiments. The information derived indicates that, as is to be expected, hills which can be compressed are less deleterious than valleys and that small valleys are less harmful than large ones. Descriptive information about the surface variations shonld be more important than single numerical values from empirical test measurements.

Scheid. The Scheid smoothness test (*13*) consists of illuminating the test surface at a low grazing angle and viewing the resulting pattern of light and shadowed areas through a microscope. It is very similar to the surface photomacrographic test in these two respects. However, instead of photographing the test surface, a numerical evaluation of smoothness is obtained by increasing the angle of illumination until a sharp decrease in resolution of the surface irregularities occurs. This decrease, which is the "end point" of the test, occurs at smaller angles for smoother surfaces.

Although the Scheid test is capable of producing numerical results directly instead of by comparison, the test is nevertheless subject to human error. The end points are a matter of the operator's opinion, and, in addition, are extremely difficult to select on uncoated stocks. It is probably for this latter reason that the Scheid correlation was not so high as that of the surface photomacrographs. (Both tests, in essence, measure the same property.) Because of the subjective nature of the evaluation, the Scheid test has been used more for research purposes, especially with coated stocks, than for quality control.

Brush Roughness. The Brush roughness test is another technique which evaluates smoothness by surface analysis. The test normally involves tracing surface irregularities with a detector needle, but it was modified by Roehr (*12*) so that, instead of recording the contour of the test surface, it electronically counts

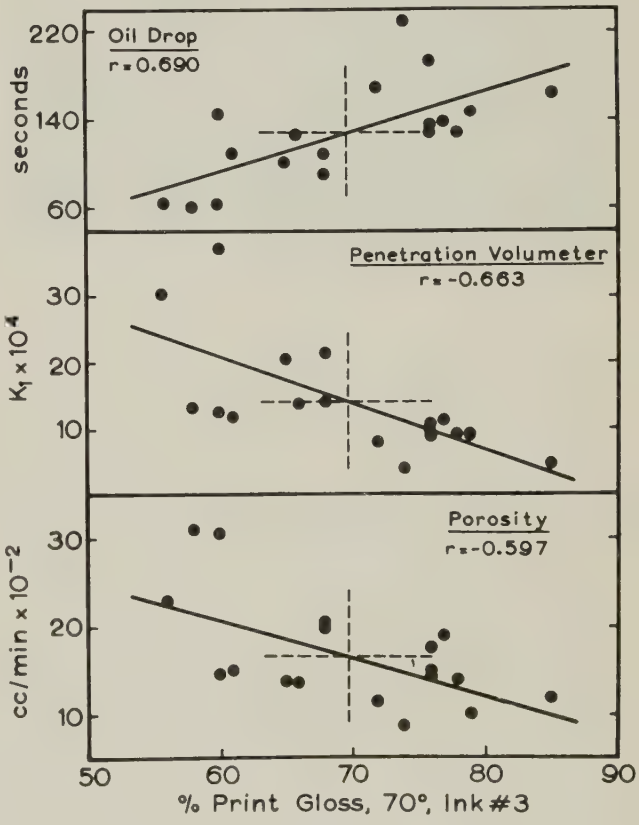

Fig. 9. Miscellaneous absorbency tests versus gloss holdout

the number and width of depressions of set magnitude. A numerical value results which states the percentage of the surface which falls below the set magnitude. Although this test fulfills the requirements of producing numerical values free from human error, its use for quality control is limited because the instrument is expensive, not commercially available, and requires skilled personnel for its operation. It is also time consuming.

Rate-of-Air-Flow Instruments. The Sheffield tester and the Bendtsen tester are two recently developed instruments which measure the rate of air flow over the test sheet. The test measurement is produced instantaneously by reading the height of a float in an

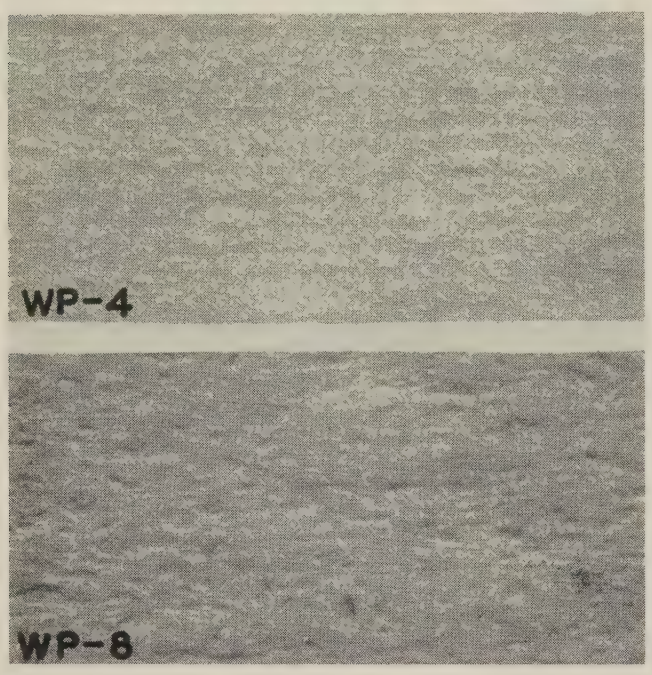

Fig. 10. Surface photomicrographs, 23 ×.

air-flow gage. Both instruments therefore possess the necessary requisites of speed, ease-of-operation, commercial availability, and objectively produced numerical values.

A TAPPI Subcommittee under the chairmanship of T. W. Lashof, of the National Bureau of Standards, has been formed to investigate techniques of operation of all the air flow instruments in current use (*22*). Until such time as the TAPPI Subcommittee makes a definite recommendation and sets up standard procedures it is suggested that the current users follow carefully the operating instructions provided by the manufacturers. For adequate sampling, the Lehigh staff has been taking six readings on each of ten 8 $^1/_2$ by 11-in. specimens.

Absorbency Tests

The operation of the Vanceometer and the ink wipe tests will be considered here because they were the most reliable of the absorbency tests tried.

Vanceometer. The Vanceometer is an instrument developed by Vallandigham (*15*) to measure absorbency by the change in 70° specular gloss with time when a thin film of oil is cast upon the specimen. The film is applied by the rolling cylinder method. The original instructions called for placing 5 drops of the test liquid directly on the sample. It was found that this procedure produced scattered results because the oil absorbed into the stock before spreading. The results obtained were more reproducible when the test liquid was placed on top of the steel roller in accordance wth the recommendations of Long (*16*).

With the survey series, it was found that the Vanceometer measurements with oils did not correlate well with gloss holdout of stocks varying widely in base gloss because the gloss of the stock showed through the transparent film of oil and influenced the photoelectric readings. Opaque systems such thinned inks (*16*) or special dispersions (*17*) correlated much better. However, with the white patent coated boards, which were very similar in base gloss, the oils correlated very well, indeed, better than the dispersions tried. The thin oil correlated best at 5 sec., the heavy oil at 20 sec., and the very heavy oil at 60 sec. The heavy oil at 20 sec. is recommended for routine testing; it produced the best correlation and also the widest range of values between the most and least absorbent stocks.

The oils, which are supplied by the Hillside Laboratories (manufacturers of the Vanceometer) are provided in bottles with self contained droppers. An experiment comparing the reproducibility of the volume delivered by the dropper and by a hypodermic needle resulted in the conclusion that the dropper was quite satisfactory and in addition was preferable for handling purposes.

Another advantage of the Vanceometer as an absorbency test instrument is that, since it is essentially a gloss meter, it can be used to measure directly the print gloss developed by various ink-board combinations. It is essential, however, that ink film thickness be controlled within reasonable limits. This is more easily accomplished by printing with constant ink on the press rather than by attempting to transfer constant ink to the stock. The prints should be dry before attempting the gloss measurement.

The Three Ink Wipe Tests. The original instructions for carrying out the ink wipe tests called for smearing a "thick" film of the specified ink on the sample and wiping it off after a specified time. The more absorbent the board, the deeper will be the discoloration of the stain. The results were to be reported numerically "by use" of a reflection densitometer.

After the initial measurements indicated that the wipe tests held promise, these tests were rerun on the boards using more explicit instructions. A 0.030 in. thick brass plate with a 1 $^1/_2$ in. square opening was placed on the sample and the opening filled with the test ink. After the specified time, the plate was removed and the ink was scraped off with a spatula and wiped dry with cleaning tissue. The Hull black ink was removed from the test specimen immediately, the Hull red after 1 min. and the K and N ink after 2 min. No other variation in time was studied.

For obtaining the numerical results, the Densichron was used with the green filter for the two Hull tests and with the yellow filter for the K and N ink test. Three types of numerical results were obtained as follows:

1. The actual reflectance of the plain board (R_o) and the actual reflectance of the stain (R), based on setting the instrument with appropriate standards, were measured. The difference between the two readings was reported as $R_o - R$.

2. Using the same data from (a), the ratio of the two reflectances was calculated and reported as R/R_o.

3. The scale of the Densichron was set at 100 with the plain board and the meter reading on the stained section noted. The resulting reading was reported as $R(R_o = 100)$.

The averaged data from ten measurements showed that there was seldom a significant difference in the numerical values of R/R_o and $R(R_o = 100)$ for a particular wipe test on a particular board. In addition, the use of the brass plate for controlling the amount and area of ink on the samples greatly reduced the standard deviations of the results.

Based on the above investigation, it can be said that not only are the three wipe tests reliable for predicting the gloss holdout properties of white patent coated board, but also that the best manner in which to express the results numerically is simply as the reflectance of the stain with the instrument set at 100 on the clean board sample.

SUMMARY

Comparison of physical test measurements with laboratory printing results on white patent coated paperboard showed the following:

1. Surface photomacrographs produced the best correlation with printing smoothness; they also show clearly the types of inhomogeneities on the surface of the stock. The Sheffield and the Bendtsen testers might be preferred for quality control because they produce numerical results free from human judgment.

2. Absorbency tests recommended for predicting gloss holdout are the three ink wipe tests (Hull red, Hull black, and K and N) and the Vanceometer, preferably 20-sec. measurements with the heavy oil.

LIMITATIONS OF THE STUDY

Those who will use the information contained herein for developing quality control programs should be well aware of the following limitations of the study:

1. The correlations, which were determined for white patent coated board, are valid only for that grade of stock. The previous survey study (*1*) has indicated that some test measurements as well as printing results are influenced by differences in surface structure such as coating, compressibility, and base gloss. Therefore, the tests should not be used to compare samples of different grades. It is probable, however, that the tests may be useful within other grades of stock which are uncoated and similar in surface properties.

2. The correlations were based on results from the letterpress printing of solids with oil-based inks and again are valid only for stocks printed by that process. Artful experience in commercial practice has shown that the relationship of the stock surface to the inked plate may differ in other cases. In letterpress printing of solids, the ink is usually "long" so that it can flow into the depressions of the stock. In halftone printing, the ink is usually a shorter one to minimize elongation and squash out of dots; some depressions which were not serious for solids may now cause missing dots. A similar situation exists in gravure. It soon becomes obvious that both the process and the properties of the inks used must be considered in establishing the usefulness of test procedures.

3. The correlations were based on a limited number of samples compared to that encountered in long range quality control measurements. The acceptance level for a test must be determined by each individual quality control supervisor depending on his particular requirements.

4. While empirical tests certainly have their place in quality control programs provided that their limitations are recognized and not exceeded, they cannot predict print quality, i.e., color, lay, mottle, of particular ink-stock-press combinations. The dependence of printing results on circumstances other than the stock itself emphasizes the need for adequate control press tests.

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An Application of the Kubelka-Munk Theory to Coated Paper Brightness

R. W. HISEY and H. W. COBB

The Kubelka-Munk theory of brightness can be applied, with certain approximations, to coated papers as well as plain papers. Experimental results are presented which show that in situations typical of coated papers, the approximations do not lead to serious error for practical purposes. The value of the theory in this application is that it can be used to predict the effect of various factors such as base stock brightness, coating brightness, and coating weight upon final brightness of the coated sheet. A few simple measurements with a brightness meter gives one the base stock brightness and the scattering and absorption coefficients of the coating color. By inserting these values and the coating weight in the equations of Kubelka and Munk, the brightness of the coated sheet may be calculated. Thus, the expense and trouble of mill trials or of measuring brightnesses in a long series of coated handsheets are minimized. This application of the theory to a practical problem is illustrated, and the severe deviations encountered when dealing with size press coated papers discussed.

At the present time, the brightness of papers is of very great importance, especially in the coated paper field. Mills are being asked for higher and higher brightness sheets, which brings up the problem of how to determine the cheapest way of achieving the desired brightness. In the case of plain papers it is relatively simple to estimate the effects of various factors on the brightness, either from experience or trial, or from the application of the Kubelka-Munk theory of diffuse reflectance of thin homogeneous layers.

In the case of coated papers, however, the situation is much more complex, as a coated sheet is composed of at least two layers of different materials. Thus, an increase in the brightness of the finished sheet may be accomplished in many ways, such as using brighter fibers, putting more or better filler in the body stock, putting more expensive pigments in the coating, putting on more coating, etc. To date, we have seen only two methods of predicting the effect of any of these changes on the finished sheet brightness. The first is to rely upon experience and rules of thumb exclusively. The second is to determine the effects experimentally, either in the laboratory or mill. Both methods have drawbacks in terms of speed, cost, and accuracy.

We wish to propose a third method, which can supplement the above two, in which the matter is reduced to a more scientific basis by the application of the Kubelka-Munk theory.

KUBELKA-MUNK THEORY

The basic Kubelka-Munk theory has been dealt with thoroughly in the literature (*1*, *2*, *3*), so only a general discussion will be given here. Kubelka and Munk have shown how brightness and opacity of a sheet are determined by two fundamental parameters—the absorption coefficient and the scattering coefficient, denoted by K and S, respectively. When light strikes a mixture of particles of pigment or wood fibers whose dimensions are of the order of the wavelength of light, part of its energy is *absorbed* and permanently changed into heat. Another part is reflected in a diffuse manner, or *scattered*. The proportions of light energy absorbed and scattered are determined by the numerical values of K and S.

In dealing with a mixture of materials, like paper or coating, the K's and S's of the materials can be averaged and the resulting brightness and opacity calculated from the Kubelka and Munk equations. It would be incorrect to average the brightnesses or opacities directly. For example, the brightnesses of a clay and a carbonate are 78.0 and 92.0. The direct average of these is 85.0. However, the brightness of a 50-50 mixture will actually be 86.8. This figure is obtained by averaging the K and S values and then calculating the brightness R from the relation $K/S = (1-R)^2/2R$.

If we consider a sheet of plain paper, or a thin layer of coating without any base stock, it is easy to see intuitively how K and S affect brightness and opacity. As K becomes smaller and S larger, brightness increases because less light is absorbed and more is scattered back when the sheet is illuminated. For the same reasons, opacity increases. This is what happens when titanium dioxide is added to a furnish. Opacity can also be increased, but with a sacrifice of brightness, by increasing K. In this case, more light is prevented from getting through the sheet, but only by being absorbed. The use of carbon black to gain opacity can be noted here.

Now consider a sheet of base stock on which there is a layer of coating. If the coating is perfectly transparent, like glass, the brightness of the coated sheet will be that of the base stock. If the coating is perfectly opaque, the base stock has no effect on the coated brightness, which is simply the brightness of the coating itself. The actual situation in most paper lies between these extremes, and it is evident that the brightness of the coated sheet will increase with the brightness of base stock, brightness of coating, and opacity of the coating, assuming the coating to be brighter than the base stock, as it usually is. Opacity of the coating layer of course, will increase with coating weight. We will assume that the coating is perfectly held up and does not strike in. Actually, some water and adhesive sink into the base stock. The effect is to reduce somewhat the brightness of the base stock. Therefore, the brightness of the coated sheet will be lowered, but this effect is small.

R. W. Hisey, Technical Service Director, and H. W. Cobb, Technical Service Engineer, S. D. Warren Co., Cumberland Mills, Me.

To deal with these general ideas quantitatively, it is necessary to turn to the Kubelka-Munk equations (*2*). For single homogeneous layers, such as body stock, much work has been done to demonstrate the validity of these equations and to produce short cuts and charts for use in solution of these equations (*4–7*). These charts are very handy, as they show the relationships among brightness, opacity, basis weight, and K and S, without resort to tedious calculations.

For multiple layered material, such as coated paper, very little applicable work has been presented in the literature (*8, 9*). The basic equation used in this work is the equation of Kubelka and Munk as transformed by Steele. This equation gives the reflectance of an homogeneous layer backed with an opaque layer of known reflectance.

$$R_{R'} = \frac{R' \sinh (y - z) + \sinh z}{-R_\infty \sinh z + \sinh (y + z)}$$

where:

R' = background reflectance
$R_{R'}$ = reflectance of the layer with a background reflectance R'.
R_∞ = reflectance of a pile consisting of an infinite number of layers.
y = $-\ln R_\infty$
S = scattering power of the material
W = basis weight
z = $SW \sinh y$

Various sources of error in this equation are discussed by Stenius and shown to be of minor importance.

There is one approximation which might be questioned in our application of this equation, and that is that R', the reflectance of an infinite thickness of body stock, is used rather than the reflectance of *one* layer of body stock backed up by layers of the coated paper. The magnitude of this effect was both calculated and measured. The calculation showed that for a typical sheet of 44-lb. (25 × 38—500) body stock of 77 brightness coated with 6.5 lb. (25 × 38—500) of 82 brightness coating this approximation should lead to a discrepancy of about 0.1 point in the observed finished sheet brightness. From this it may be seen that in the normal range of body stock weights and brightnesses, the simplest assumption leads to a value which is very close to the more exact solution.

In Fig. 1 are experimental results with C1S paper which also support the approximation quite well. From Fig. 1, nos. 1 and 2, it will be noted that the final coated brightness measurement did not change appreciably when the top sheet was backed with a pile of body stock or a pile of coated sheets. This is further confirmed by nos. 3 and 5 showing that the body stock brightness increased only 0.3 point when backed by coated sheets. It is interesting to note from nos. 4 and 5 that, at the same time, the body stock brightness *decreased* 0.3 point in the coating process, probably due to coating adhesive strike-in. Thus, the error in the approximation is about balanced out by another error, that due to the strike-in.

Table I

Base stock brightness	72.5
Coating brightness	86.5
Coating S	1770 sq. cm./g.
Coating K	19.5 sq. cm./g.
Coating weight (one side)	7 lb. (25 × 38—500)
Calculated sheet brightness	79.7
Observed sheet brightness	78.7

Bodystock 62-lb. (25 × 38—500). Coating 9-lb. (25 × 38—500).

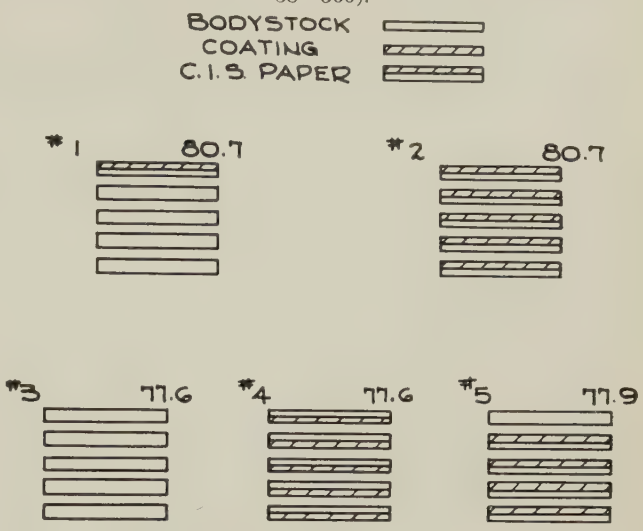

Fig. 1. Brightness versus pile arrangement coated one side paper

In Table I is shown a further check of the equation where the brightness of a final uncalendered coated sheet is calculated from the body stock brightness and the coating K and S.

This check is close enough to give more assurance that the error in neglecting strike-in, body stock basis weight, nonuniformity, etc. is not excessively large.

The net result is that we feel confident in the application of the above equation to coated papers of the normal type where the coating is well held up and both coating and body stock are relatively bright and opaque, and most especially for the calculation of changes, rather than absolute values.

One further approximation is necessary to apply the equations to the finished, calendered sheet. It is necessary to have a figure for the brightness of the body stock after calendering. At first we made the assumption that all the transparentizing was concentrated in the coating, but recently an indirect check has shown that our body stock itself may drop some 1 to $1^1/_2$ points in brightness when the coated sheet is calendered. This effect is of minor importance when the coatings are heavy, but may be very important in light coatings.

A PRACTICAL APPLICATION

Let us consider a practical sort of example of the use of the Kubelka-Munk theory to provide useful information for mill decisions. The problem is very simply stated. A given coated two side paper has a brightness of 80.0; how can it be raised to 82.0? The first step is to get the basic data necessary and calculate K and S of the calendered coating, approximately. This is done by the use of films of coating deposited on glass and laboratory handsheets both calendered and uncalendered. The results are shown in Table II.

Table II

Body stock brightness	79.0
Coating weight (per side)	8 lb. (25 × 38—500)
K of coating (after calendering)	27.1 sq. cm./g.
S of coating (after calendering)	1100 sq. cm./g.
Brightness of final sheet	80.0

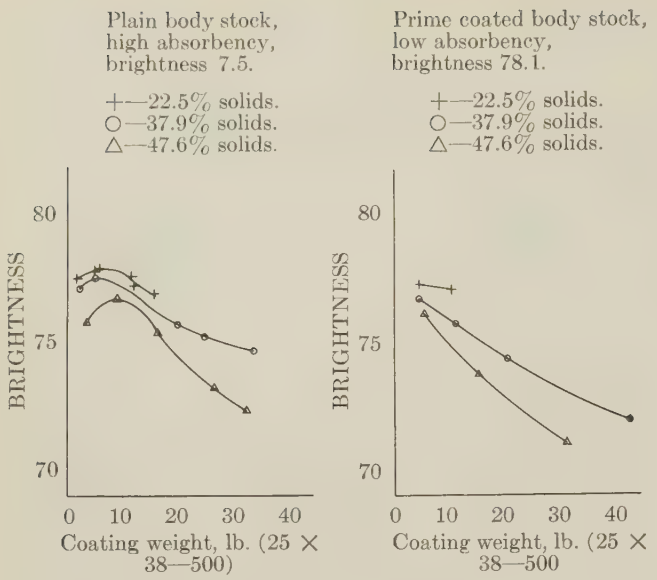

Fig. 2. Sheet brightness versus coating weight and solids

Using the Kubelka and Munk formulas, we can proceed to calculate the effect on the final coated sheet brightness if the coating weight is changed, or if coating brightness is increased by changing K, or if coating brightness is increased by changing S, or if the body stock brightness is changed. The results of these calculations were graphed, and in Table III are summarized the various ways calculated of achieving 2 points increased brightness in the final sheet. From this it can be seen that little should be done on increasing coating weight or decreasing the coating K, and that effort should be spent in increasing the coating S and the body stock brightness.

We will not consider here the problem of increasing of body stock brightness, as this has been well covered before in the literature. However, the question of increasing the S of the final calendered coating is of interest. For example two pigments, A and B, which were investigated had brightnesses of 90.5 and 89.3 when taken in the powder form. At first glance, the difference of 12 points does not seem of great importance. However, when the S for each pigment is found for the plain pigment, the pigment as a coating color with a normal amount of adhesive, and the pigment coating after calendering, a different picture appears. The results are shown in Table IV.

It appears that, in the final calendered coating, pigment A is about 50% better than B in hiding power, S. Also, the brightness difference has increased from 1.2 points to 3.4 points, or almost tripled. Thus pigment A is much to be preferred to pigment B, other factors being equal.

It should be noted that the previous discussion has been of papers with a fairly heavy coating applied

Table III

Change to be made to brighten sheet 2 points	*Amount of change necessary*
Increase coating weight	Impossible to achieve desired result
Increase coating brightness by changing K	5.3 points increase in coating brightness
Increasing coating brightness by changing S	3.1 points increase in coating brightness
Increasing body stock brightness	4.0 points increase in body stock brightness

Table IV

	Pigment A	*Pigment B*
Powder brightness	90.5	89.3
Powder S, sq. cm./g.	2800	2200
Coating color S, sq. cm./g.	1400	1400
Calendered coating color S, sq. cm./g.	1000	700
Calendered coating color brightness	80.8	77.4

and in cases where this coating is well held up. In these cases, there is a distinct layer of solid coating on top of a layer of body stock. In our work we have found that the Kubelka-Munk equations are applicable in the normal fashion when these conditions are met.

SIZE PRESS COATINGS

Size press coating, however, does not meet the above conditions. In putting a low solids coating on an absorptive sheet the coating does not form a solid layer on top of the sheet, but instead strikes into the sheet and dries in a disperse form. In this form there is more surface area for light scattering, and thus the apparent brightness of the coating is raised. This leads to situations in which the brightness of a coated sheet can be higher than that of either the body stock or the coating.

In order to check the above theory of disperse drying a set of tests were run, in which a plain body stock and a prime coated body stock were both coated at low solids with varying weights of coating. Both body stocks were about the same brightness and the coating showed a lower brightness in the film measurements than either body stock. The above theory predicts that with increasing coating weight the brightness of the plain body stock should rise and then fall, while that of the prime coated body stock should steadily fall. Also, this theory predicts that the brightness will be lower with a higher solids coating, in both cases. Data in Fig. 2 show that this expectation was met. Unfortunately no quantitative theory has been developed to account for this effect and allow predictions to be made.

CONCLUSIONS

In conclusion, the Kubelka and Munk theory of diffuse reflectance may be applied to coated papers in the normal range of brightness, providing that the coating is of reasonable weight and is well held up. If these conditions are not met, severe deviations occur.

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Highly Purified Cellulose from Wood

W. H. RAPSON and G. K. MORBEY

Cellulose containing less than one part of xylan and mannan per thousand parts of glucan and still retaining its fibrous characteristics has been prepared from spruce wood. As a prerequisite, a chromatographic method of determining xylan and mannan in such low concentration in glucan was developed. A spruce sulphite pulp of the highest purity commercially available was extracted in separate batches with increasing concentrations of sodium, lithium, and benzyltrimethylammonium hydroxide, at 5% consistency, for 4 hr., at both 25 and 95°C., and the xylan and mannan were determined. Curves show the lowest content of these sugars (0.1% or less) with 4 *N* NaOH and 4.73 *N* (saturated) LiOH at 25°C., with yields of 95.5 and 97.3% of the original pulp, respectively, with very little drop in viscosity. It is concluded that the resistant mannan and xylan are not chemically combined with the cellulose molecule, but are merely impurities difficult to remove.

It is desirable to produce wood pulps which are as nearly pure cellulose as possible, especially for the production of certain cellulose derivatives. Normal pulp purifying techniques always leave a small quantity of hemicellulose with the cellulose. The great difficulty of removing all the mannan and xylan by any means which does not disrupt the cellulose chains themselves has frequently led to speculation that anhydromannose and anhydroxylose units might be an integral part of the wood cellulose molecule.

The resistance of mannan and xylan to removal from wood pulp by such drastic reactions as nitration (*1*), xanthation (*2*), or hydrolysis (*3*) lent support to the chemical bond concept. Centola (*4*) was not able to separate completely the nitrates of other carbohydrates from cellulose nitrate and concluded that the nonglucose sugars to some extent form part of the molecular chains of cellulose. His later work with highly purified pulp (*5*) led him to the same conclusions. On finding a disaccharide of glucose and mannose in the hydrolysate of the alkali-extracted residue of softwood holocellulose, Leech (*6*) stated: "The important implication is that glucose and mannose units are almost certainly linked in the alpha-cellulose of slash pine." Anthis (*7*) isolated 4-O-β-glucopyranosyl-D-mannose on acetolysis of slash pine alpha-cellulose, which showed that some glucose and mannose units are linked together in alpha-cellulose. Das, Mitra, and Wareham (*8*) isolated a glucose-xylose-arabinose compound from cotton alpha-cellulose and concluded that these units were present in the cellulose structure as mixed crystals.

Snyder and Timell (*9*) removed mannose, xylose, and uronic anhydride units from balsam firwood with three alternate chlorinations and extractions with 17.5% NaOH, but serious degradation occurred during the purification, the final viscosity being only 30% of the original. Only qualitative tests for the sugars are given for these experiments. Hamilton and Quimby (*10*) were able to lower the xylan content of sulphite pulp from western hemlock to 0.2% and the mannan content to 0.7% by extraction with 10% NaOH three times followed by 18% NaOH three times. Slightly lower values (0.09% xylose and 0.6% mannose) were reported in holocellulose after milling in a Wiley mill to destroy the fiber structure and then applying the same multiple extractions.

Matsuzaki, Hatano, Abe, and Sobue (*11*) stated that it is difficult to reduce the pentosan content below 0.5% by intermicellar reactions such as acid hydrolysis or extraction with hot dilute alkali, whereas by intramicellar reactions such as cold alkaline refining pentosan contents below this level could be achieved. Treating red pine pulp with 14% NaOH at 20°C for 30 min. lowered the pentosan content from 2 to 0.39%, while dissolving 11% of the pulp.

Matsuzaki and Ward (*12*) on denitration and hydrolysis of the nitrate of spruce sulphite pulp were unable to obtain fractions containing less than 0.4% mannose and 0.2% xylose. They state that this does not imply that the nonglucose sugars take part in the formation of cellulose chains, but that further investigation is necessary to reach definite conclusions.

That hemicellulose is only physically associated with cellulose was suggested by Hawley and Norman in 1932 (*13*). Recent investigators have indicated that the xylan chain could fit tightly into the cellulose matrix and xylan molecules could be entangled with protective cellulose molecules. In such cases the xylan molecules might be bound to cellulose by large secondary forces. This type of adsorption of xylan on cellulose has been shown by Yllner and Enstrom (*14*), who have recently published results to support an hypothesis of xylan crystallization with cellulose (*15*). Considerably less work has been done on the mannan structure in cellulose, but it has been shown by Timell and Tyminski (*16*) that glucomannans are extremely resistant to alkali extraction and consequently their presence need not indicate a chemical bond between mannose units and cellulose.

It was with these concepts in mind that the present attempt was made to produce cellulose free from nonglucose sugar units from wood. If such a product could be obtained in fibrous form with reasonably high viscosity, it would indicate that the other sugar units are not part of the molecular chain of cellulose, and that attempts to prepare pure cellulose commercially have a reasonable chance for success.

To simplify the problem, one of the purest wood pulps commercially available was chosen as the starting material, namely "Acetacell" made from sprucewood by Canadian International Paper Co. at Temiskaming, Que. This was extracted with increasing concentra-

W. H. Rapson, Professor of Chemical Engineering, and G. K. Morbey, Graduate Student, Department of Chemical Engineering, University of Toronto, Toronto, Ont.

tions of sodium, lithium, and benzyltrimethylammonium hydroxides at 25 and at 95°C. After thorough washing the resulting pulps were analyzed for mannan and xylan.

Published methods of sugar chromatography were found to be insufficiently sensitive to determine the exceedingly small quantities of mannose and xylose in the presence of very large amounts of glucose. Therefore, a method of accomplishing this had to be developed before the experimental pulps could be analyzed in a reliable manner. The method finally evolved eliminated removal of the sugars from the paper with the inherent errors, and also eliminated the indirect determination of sugars by the nonspecific chemical methods usually applied. The direct visual comparison with known amounts of the pure sugars spotted on the same paper chromatogram makes it certain that the very small quantities of mannan and xylan reported here are actually present in these minute amounts. This method is not suited to much larger amounts of sugars.

ANALYTICAL

Normal quantitive procedures for analyzing sugar mixtures were first investigated. It was found that any determination involving the removal of a separated sugar from a paper chromatogram could not be used to give accurate results because of the relatively high paper blanks when determining quantities of sugar less than 0.5% of the total mixture. However, by using a sufficiently sensitive spray reagent it was possible to determine the mannose and xylose in the range of 0.05 to 1.5% of the glucose by visual comparison with known sugar solutions of similar composition to the pulp hydrolyzate.

Aniline phthalate had been used by Jayme and Tiedke (*17*) for the detection of mannose and xylose by this method, but for very small quantities of sugar it was clearly necessary to use a more sensitive color spray reagent. Sattler and Zerban (*18*) used a 0.3% ethyl alcohol solution of *p*-amino-hippuric acid and

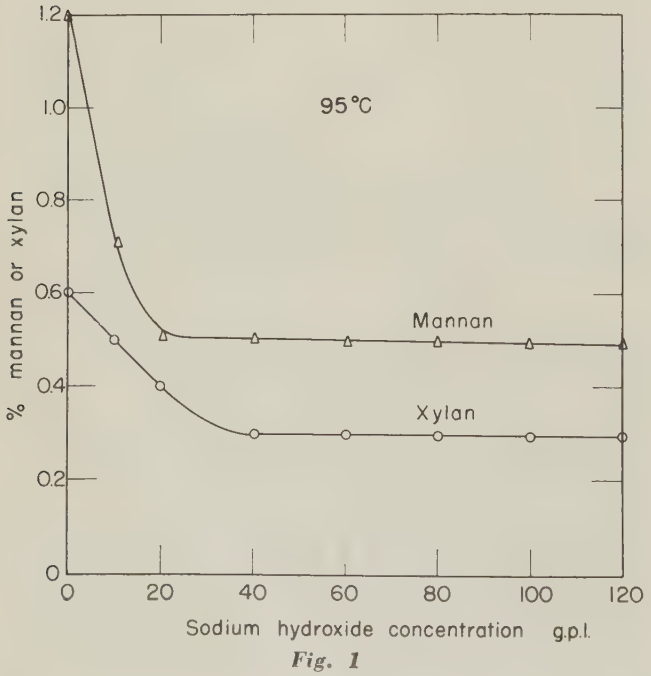

Fig. 1

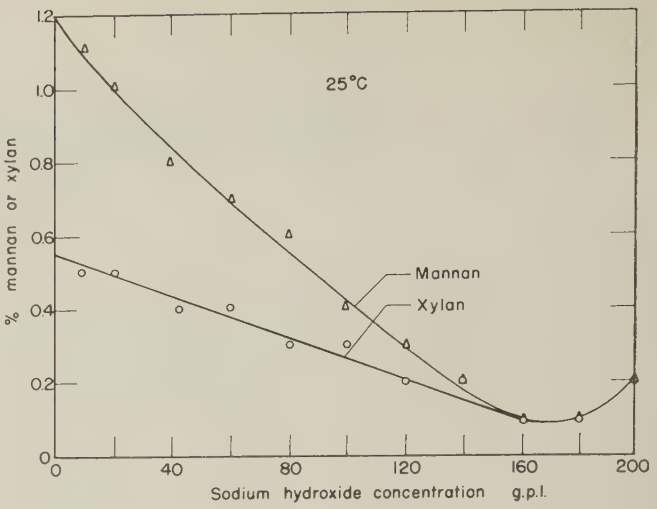

Fig. 2

claimed a visual sensitivity of 1 microgram of sugar with ultraviolet light. Experiments performed using *p*-anisidine hydrochloride in butanol showed that this chemical was not satisfactory for visual comparison in the low range involved.

Timell, Glaudemans, and Currie (*19*) used the phosphate of 2-aminobiphenyl in the spectrophotometric determination of sugars and indicated that it was an extremely sensitive spray reagent. As little as 0.1 microgram could be detected visually on a paper chromatogram. Aldohexoses gave a green-brown, pentoses a bright red and hexuronic acids an orange color. This reagent was adapted to this investigation by developing standard solutions of similar composition to the unknown and comparing their chromatograms visually after spraying with this reagent. The method was sufficiently sensitive to measure mannose and xylose concentrations to the nearest 0.1% in the range 0.0 to 1.5% Since the spruce pulp "Acetacell," which was used as the starting material, contained only 1.2% mannan and 0.6% xylan, this method of analysis was applicable to all the pulps produced from it in this investigation.

EXPERIMENTAL

Twenty grams of moisture-free pulp was weighed out, made up to 2% consistency with distilled water and left to soak overnight. The slurry was filtered on a 100-mesh screen, the fines being recovered by refiltering through the pulp mat. The sample was then centifuged, torn to pass through a 2-mesh wire screen and mixed thoroughly. The moisture content was determined.

For the hot treatments each sample was placed in a 1-qt. glass fruit jar which was sealed and placed in a water bath at 95°C. for 1 hr. Solutions of sodium hydroxide, lithium hydroxide, and benzyltrimethylammonium hydroxide were made up to produce the required alkali concentration at 5% consistency after mixing with the pulp, and heated to a temperature close to boiling. The hot alkali solution was added to the hot pulp sample and thoroughly mixed for 5 min. with a mechanical stirrer. The jar was returned to the bath and the extraction carried out at 95°C. for 4 hr. The extraction was ended by filling the jars with distilled water and mixing with a mechanical stirrer. The slurry was filtered through a 100-mesh

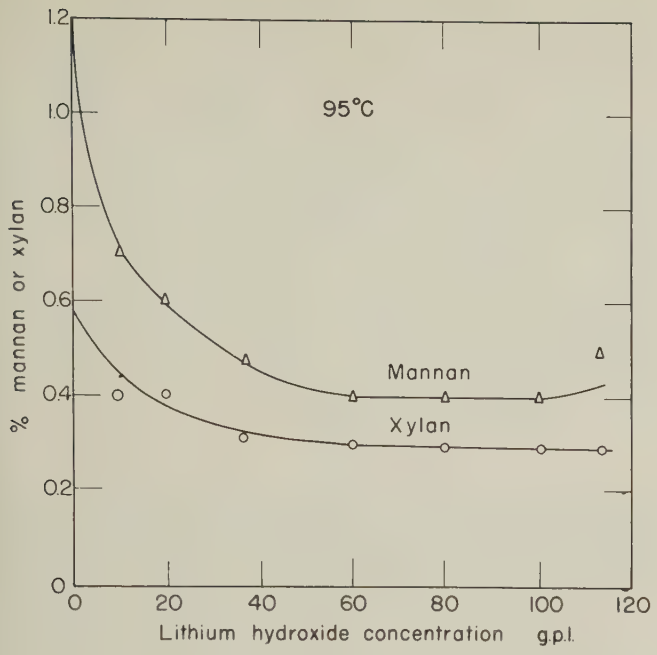

Fig. 3

screen, the first portion being returned to recover the fines. The mat was then washed with 4 to 5 l. of distilled water to remove the remaining alkali and quantitively made into sheets using the standard sheet machine and stirrer. The sheets were air dried for 48 hr. and the yield was determined.

The cold extractions were carried out at 25°C. by a similar procedure to that used in the hot extraction. The pulp was mixed with the alkali at 25°C., held at that temperature for 4 hr. and washed.

The cupriethylenediamine viscosity of a selection of the extracted samples was determined using TAPPI Standard T 230 sm-50.

The extracted pulps were analyzed by measuring the sugar content of the pulp hydrolysates, which were produced by a modification of the hydrolysis method of Saeman *et al.* (*20*).

One and a half grams of air-dried, 40-mesh Wiley-milled pulp was treated with 15 ml. 72% H_2SO_4 (sp. gr. 1.64) for 4 hr. at room temperature. The sample was stirred as required to effect solution of the pulp. Four hundred and eighty milliliters distilled water was then added and the solution was boiled under reflux for 4 hr. at atmospheric pressure. After cooling, the solution was neutralized by stirring with freshly washed Amberlite I.R. 45 ion exchange resin until pH 4 was obtained. The sample was then separated from the ion-exchanger by filtering through a sintered-glass funnel, the ex-

Table I. NaOH Extraction at 25°C., Followed by 40 g.p.l. NaOH at 95°C.

25°C. NaOH, g.p.l.	*After cold extraction*			*After 40 g.p.l. NaOH at 95°C.*		
	Residue, %	*Mannan, %*	*Xylan, %*	*Residue, %*	*Mannan, %*	*Xylan, %*
0	100	1.2	0.6	93.5	0.5	0.3
10	100	1.1	0.5	96.3	0.9	0.5
20	100	1.0	0.5	96.7	0.8	0.5
40	100	0.8	0.4	96.3	0.7	0.4
60	99.5	0.7	0.4	95.0	0.6	0.4
80	99.0	0.6	0.3	95.0	0.5	0.3
100	98.5	0.4	0.3	95.0	0.1	0.2
120	98.5	0.3	0.2	95.5	0.2	0.2
160	98.5	<0.1	0.1	95.5	<0.1	0.1
200	99.0	0.2	0.2	94.5	0.1	0.2

Table II. Effect of Mixing at 25°C. and Then Heating to 95°C.

NaOH, g.p.l.	*1 hr. at 25° C., then 4 at 95°C.*			*Mixed and 4 hrs. at 95°C.*		
	Residue, %	*Mannan, %*	*Xylan, %*	*Residue, %*	*Mannan, %*	*Xylan, %*
20	92.5	0.8	0.5	94.5	0.5	0.3
40	92.5	0.7	0.4	93.5	0.5	0.3
80	91.0	0.5	0.3	92.5	0.5	0.3

changer being quantitively washed with 300 to 400 ml. distilled water. The resulting solution was adjusted to pH 3 to 4 with glacial acetic acid and concentrated to approximately 10 ml. by evaporating under vacuum. The concentrated sugar solution was transferred to a 25 ml. volumetric flask with a 5-ml. pipet, together with distilled water washings from the evaporation flask. Phenyl mercuric acetate (1 p.p.m.) was added as a sugar preservative and the solution made up to volume with distilled water.

Using an "Agla" micrometer syringe (Burroughs Welcome Co. London) 0.02 ml. of the sugar concentrate was spotted accurately on Whatman no. 3 chromatograph paper. Test solutions of similar composition to the sugar solution were spotted at the side of the unknown. It was found convenient to develop four samples, one unknown and three known, each 2 in. apart on a chromatogram 9 in. wide. The chromatogram was developed using the descending solvent technique with the machine direction of the paper perpendicular to the solvent front. The solvent system used to separate glucose, mannose and xylose was N-butanol:pyridine:water:benzene in the ratio 5:3:3:1. The chromatograms were developed for 24 hr. at room temperature and air dried in a fume hood.

The air dried chromatograms were sprayed lightly and evenly with a solution made by dissolving 2 g. 2-aminobiphenyl in 100 ml. glacial acetic acid and adding 1.3 ml. 85% phosphoric acid. To develop the color the chromatograms were heated for 2 to 3 min. in an oven at 105°C. The color and size of the unknown spot was compared visually with the known

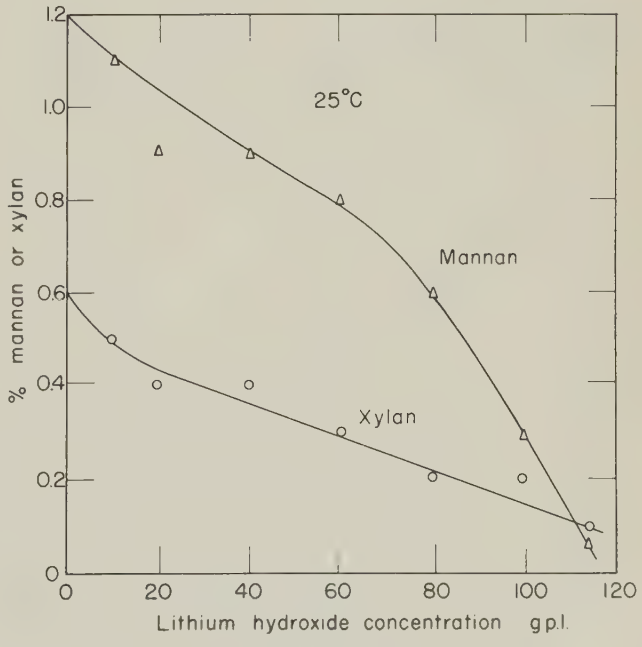

Fig. 4

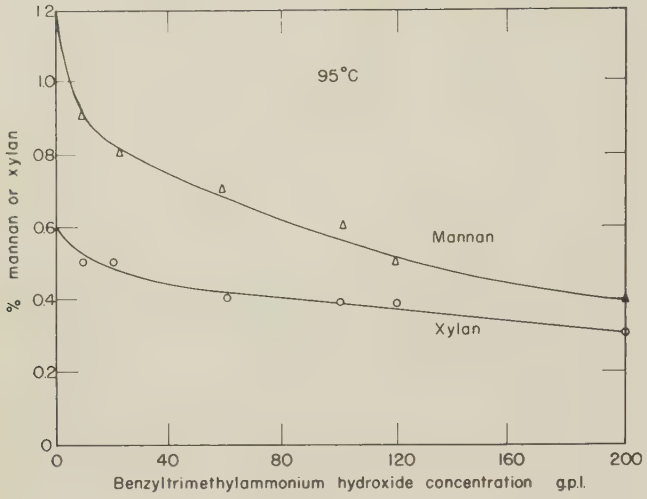

Fig. 5

sugar samples until it was bracketted between two known concentrations of sugar. The analysis was further checked by comparing the sugars from pulps given various alkali treatments on one chromatogram. This procedure was used successfully to analyze known sugar solutions of similar composition to those produced in the pulp hydrolysates.

DISCUSSION

Extraction of the pulp with increasing concentration of sodium hydroxide at 95°C. (Fig. 1) lowered the mannan content from 1.2 to 0.5% with 20 g.p.l. NaOH, and the xylan from 0.6 to 0.3% with 40 g.p.l. NaOH, but higher caustic soda concentration did not lower the mannan and xylan further.

The same treatment at 25°C. did not lower the mannan and xylan as much at the lower concentrations (Fig. 2), but with increasing sodium hydroxide concentration both values dropped steadily to 0.1% at 160 g.p.l. NaOH. Higher concentrations of sodium hydroxide dissolved less mannan and xylan.

The results with lithium hydroxide at 95°C. (Fig. 3) are somewhat similar, the minimum mannan being 0.4% and xylan 0.3%. At 25°C. the lithium hydroxide (Fig. 4) removed the xylan to about the same extent as the sodium hydroxide at the same concentration, but it was much less effective in removing mannan at

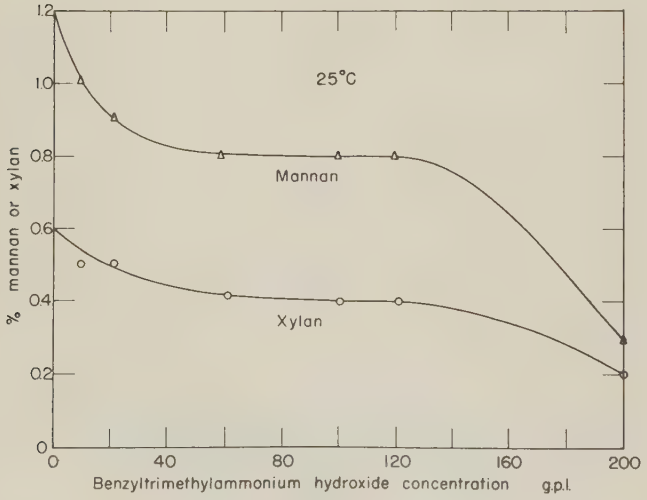

Fig. 6

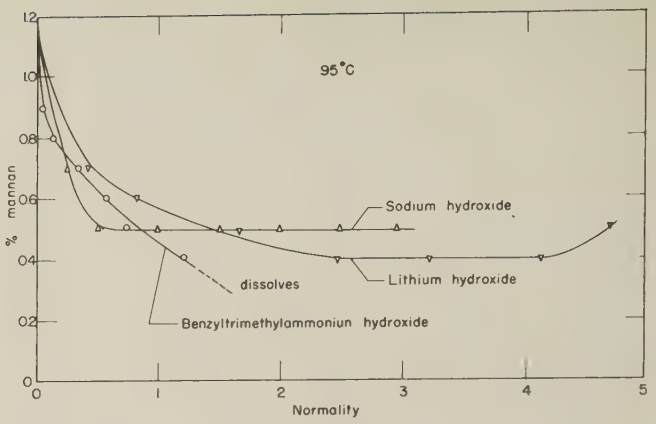

Fig. 7

the lower concentrations, although it brought both mannan and xylan to the same minimum level of about 0.1% at its saturation concentration (4.73 molar).

The benzyltrimethylammonium hydroxide behaved in a similar manner to the other alkalies in removing mannan and xylan at 95°C. (Fig. 5). However, at 25°C. it was less effective for removing mannan and xylan than sodium and lithium hydroxide when the concentrations were expressed in grams per liter, but more effective when molar concentrations were plotted. The superiority did not continue over the whole concentration range, for the benzyltrimethylammonium hydroxide dissolved the cellulose completely before the mannan and xylan content of the residue was reduced to the low level achieved with sodium and lithium hydroxides (Fig. 6).

Plotting the mannan and xylan concentrations against normality gave very similar results at 95°C. for all three bases. This would seem to indicate that the hydroxyl ion concentration is more important than the nature of the cation for hot alkaline extraction of hemicellulose (Fig. 7).

The same type of plot for the results at 25°C. shows that the nature of the cation is much more important at the lower temperature (Figs. 8 and 9). The effectiveness of extraction of the hemicelluloses at the lower concentrations seems to increase with increasing molecular weight of the cation. Since the degree of swelling increases with the molecular weight of the cation, this probably makes it easier for the alkali to dissolve the mannan and xylan. The weight of the benzyltrimethylammonium ion is so high that it dissolves

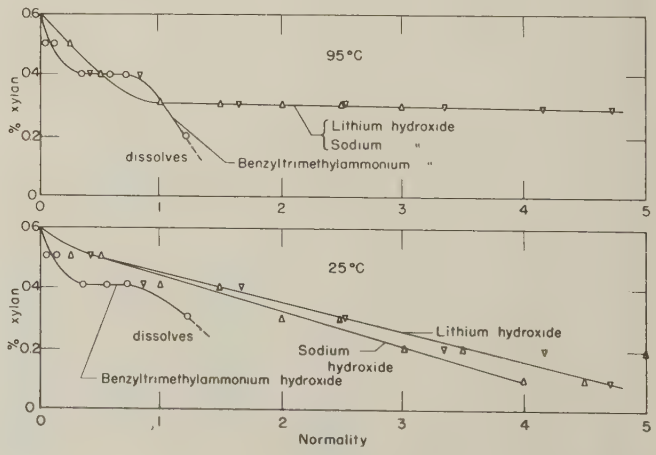

Fig. 8

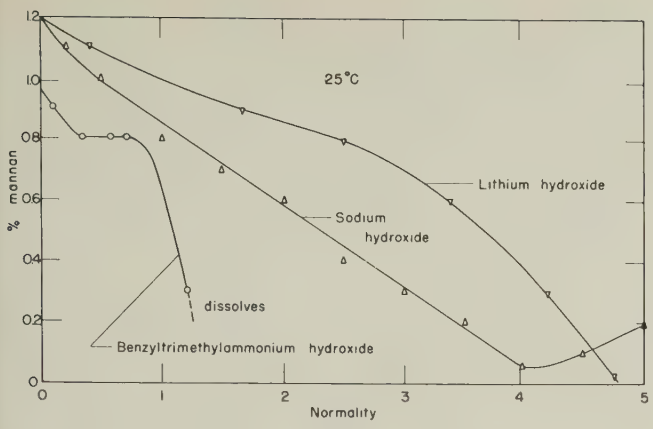

Fig. 9

cellulose completely in 2 *N* solution. It does not dissolve the mannan and xylan to leave very low levels in the residue before it dissolves the cellulose itself. Therefore it is not a suitable reagent for producing very pure cellulose.

Figure 10 shows the amount of material dissolved from the pulp by the three alkalies at different concentrations and temperatures. Sodium and lithium hydroxide lower the mannan and xylan content to 0.1% of the pulp without dissolving very much of the cellulose. At 95°C. much more of the pulp is dissolved without removing as much mannan and xylan. The benzyltrimethylammonium hydroxide dissolves a great deal of the pulp above 1 *N* concentration, and all of it at 2 *N*.

Since extraction with sodium hydroxide at 25 and at 95°C. showed some different tendencies, it was thought that applying both treatments successively to the same sample of pulp might lower the mannan and xylan to still lower levels. Therefore, the samples which were treated at 25°C. over the whole range of sodium hydroxide concentrations were washed and then treated with 40 g.p.l. NaOH at 95°C. (Table I). The results for xylan were almost identical with those with the cold sodium hydroxide treatment alone, but for mannan the figures were slightly lower at each caustic concentration. The minimum level for xylan and mannan was visibly less than 0.1%. Therefore, treatment with 160 g.p.l. NaOH hydroxide at 25°C. at 5% consistency for 4 hr., followed by treatment with 40 g.p.l. NaOH at 95°C. under the same conditions gave the pulp sample with the lowest concentration of mannan and xylan, less than 0.1% of each. However, this level is not very much below that obtained with the same cold caustic treatment alone.

In another series of experiments (Table II) the hot caustic extraction was carried out by mixing the sodium hydroxide solution and the pulp at 25°C. and then heating to 95°C., instead of mixing the pulp and liquor at 95°C. It is interesting that more cellulose dissolves

Table III. NaOH Extraction After Treatment with 10% $NaBH_4$

$NaBH_4$	*NaOH, g.p.l.*	*Temp., °C.*	*Residue, %*	*Mannan, %*	*Xylan, %*
No	0	..	...	1.2	0.6
No	40	95	93.3	0.5	0.3
Yes	40	95	100	0.9	0.4
No	100	25	98.5	0.4	0.3
Yes	100	25	100	0.9	0.5

Table IV. TAPPI Cupriethylenediamine Viscosity of Alkali Extracted Pulps

Pulp treatment	*Viscosity, cp.*	*Mannan, %*	*Xylan, %*
Untreated Acetacell	22.2	1.2	0.6
1 *N* hot NaOH	20.6	0.5	0.3
1 *N* hot NaOH (under N_2)	20.9	0.5	0.3
2.5 *N* hot NaOH	20.5	0.5	0.3
2.5 *N* cold NaOH	21.3	0.4	0.3
4 *N* cold NaOH (a)	19.5	<0.1	0.1
(a) followed by 1 *N* hot NaOH	12.4	<0.1	<0.1
1.67 *N* cold LiOH	21.7	0.9	0.4
4.73 *N* cold LiOH	21.8	<0.1	0.1
3.38 *N* hot LiOH	21.1	0.4	0.3
0.72 *N* cold $C_6H_5CH_2N(CH_3)_3OH$	21.0	0.8	0.4
0.72 *N* hot $C_6H_5CH_2N(CH_3)_3OH$	19.2	0.5	0.4

under these conditions, presumably due to the higher swelling at the lower temperature, but the removal of mannan and xylan was not so good at the lower caustic concentrations as it was when the pulp and caustic were mixed at the higher temperature.

To find out what effect the carbonyl groups present in the pulp were having on the extraction, the original pulp was treated with 10% sodium borohydride on pulp, at 3% consistency, for 18 hr. at room temperature, to reduce the carbonyl groups to hydroxyl groups. The pulp was subsequently extracted with 40 g.p.l. NaOH at 95°C. for 4 hr. at 5% consistency, and with 100 g.p.l. NaOH at 25°C. under the same conditions (Table III).

The treatment with sodium borohydride lowered the amount of pulp dissolved by the sodium hydroxide treatments almost to nothing. Only between a third and a half of the amount of mannan and xylan was removed by the sodium hydroxide after the borohydride treatment. Therefore, it must be concluded that reduction of the carbonyl groups to hydroxyl diminishes the solubility of the mannan and xylan in the caustic soda solution as it does that of cellulose.

An hypothetical explanation of this phenomenon may be offered. It is suggested that the solution of the mannan and xylan in caustic alkalies occurs in part by a degrading reaction similar to that elucidated for cellulose (*21*, *22*).

A similar "peeling off" reaction may be assumed to take place from the potential aldehyde end groups of any polymeric carbohydrate molecules, continuing to remove sugar units consecutively until stopped by the formation of carboxyl group on the ends of the shortened

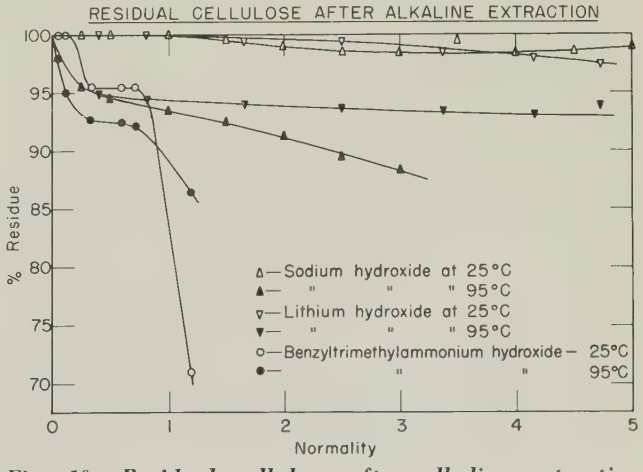

Fig. 10. Residual cellulose after alkaline extraction

molecules. The remaining stabilized molecules may be so shortened that they are soluble in the caustic soda solution, resulting in separation of mannan and xylan from the cellulose.

Since treatment with borohydride oxidized carbonyl groups to hydroxyl groups, the "peeling off" reaction cannot begin. Therefore, the mannan, xylan and cellulose molecules are not shortened and thus fewer of them are dissolved by the alkali treatments. This would account for the higher weight of residue and for the higher mannan and xylan content of the residual cellulose after alkaline extraction following the borohydride treatment.

No attempt was made to exclude air during the alkaline extractions. To test whether or not this had any significant effect, one extraction with 40 g.p.l. NaOH at 95°C. was carried out displacing the air with nitrogen. There was no effect on the removal of mannan and xylan, and the viscosity dropped only from 20.9 to 20.6 centipoises due to the air. Since the amount of material dissolved was only slightly less (probably within the experimental error of the determination), it may be concluded that the air had very little effect in these experiments.

To show the effect of the alkaline extraction on the degree of polymerization of the cellulose, the viscosity was determined by the TAPPI method in cupriethylenediamine solution (Table IV). In no case was the drop in viscosity very serious, except for the extraction with 160 g.p.l. NaOH at 25°C. followed by extraction with 40 g.p.l. NaOH at 95°C.

CONCLUSIONS

The resistant mannan and xylan units can be removed from purified spruce pulp by suitable sodium or lithium hydroxide extractions at 25°C. to the extent that less than 1 part of each in 1000 parts of glucose remain. The extraction can be performed with little loss in yield and no serious degradation while still retaining the fibrous characteristics of the pulp.

These results indicate that mannan and xylan units do not form part of the cellulose molecule, but by virtue of their chemical similarity to cellulose are very difficult to separate from it. The presence of uronic acids in all the pulp hydrolysates suggests that the anhydroxylose units are probably present as xylan polyuronides. Investigations by Timell and Tyminski (*16*) indicate that the mannose units are probably present as glucomannan.

It can be concluded that by extractive techniques wood pulp can be purified to leave a fibrous residue of high molecular weight which is essentially pure cellulose containing only anhydroglucose units.

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Strength Characteristics of Bleached Sulphate and NSSC Hardwood Pulps

K. G. CHESLEY

Commercial bleached and unbleached sulphate and bleached and unbleached neutral sulphite semichemical pulps made from mixed southern oaks have been tested in the laboratory. The results show that unbleached NSSC pulp is weaker than unbleached kraft but the bleached NSSC pulp is stronger than either bleached or unbleached kraft.

Bleached sulphate and neutral sulphite semichemical pulps have been made commercially from southern oaks by the Crossett Paper Mills, Crossett, Ark. This unusual situation wherein the two different pulping processes are used in the same plant and on the same raw material has given an opportunity to make this comparative study on the two pulps. Actually, the two pulps are run through the same pulp mill and bleach plant intermittently.

K. G. Chesley, Director of Research, The Crossett Co., Crossett, Ark.

PROCEDURE AND RESULTS

A description of the plant has been published (*1*, *2*) so it will not be described in detail. In brief, the process is as follows:

The southern oaks which are used as a raw material are made up of a mixture of approximately 60% red oaks and 40% white oaks. The predominant specie in the red oak group is the southern red oak (*Quercus fal-*

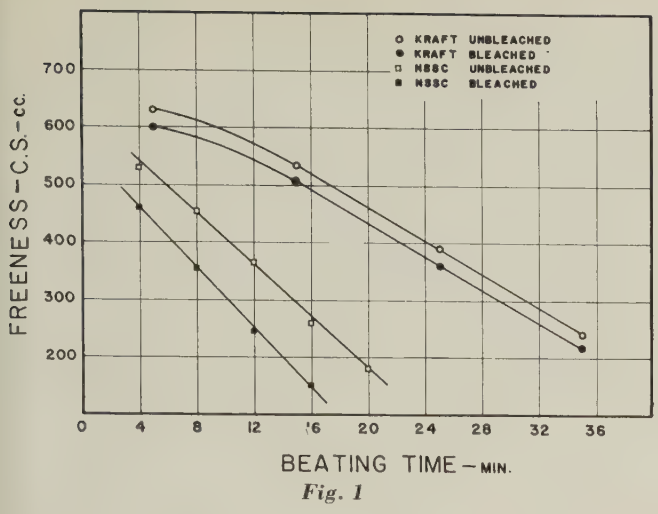

Fig. 1

cata). The white oak group is composed primarily of post oak (*Quercus stellata*) and white oak (*Quercus alba*). The data for the pulping and bleaching process are given in Table I. Some general data on the pulps are given in

Table I. Cooking and Bleaching Data for Pulping Hardwood by the Kraft and Neutral Sulphite Semi-Chemical Processes

	Kraft hardwood	*NSSC hardwood*
Cooking Data		
% Active alkali: (NaOH + Na_2S) expressed as Na_2O	19.5	...
% Sulphidity (based on total Na_2O)	23.0	...
% Na_2SO_3	...	20.0
% Na_2CO_3	...	4.0
Cooking time, hr.	3	3¾
PN or GN	12	70
Yield, O.D.	48%	58%
Bleaching Data		
% Cl_2—1st stage	4.5	17.5
% Caustic—2nd stage	2.0	5.0
Extracted P.N.	3.0	3.0
% Cl_2—hypo stage	0.7	1.5
% Cl_2 4th stage	0.45	...
Brightness	85–88	85–88

Table II. As will be seen from Table II, the primary differences in the unbeaten pulps are in their viscosity and freeness. The initial freeness of both bleached and unbleached kraft pulp is appreciably higher than the

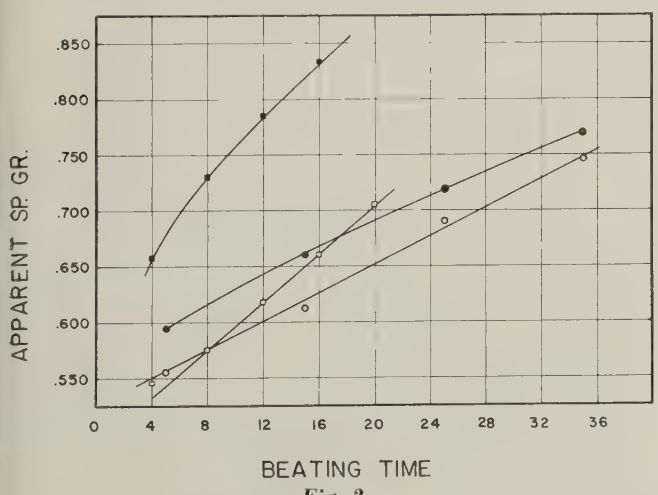

Fig. 2

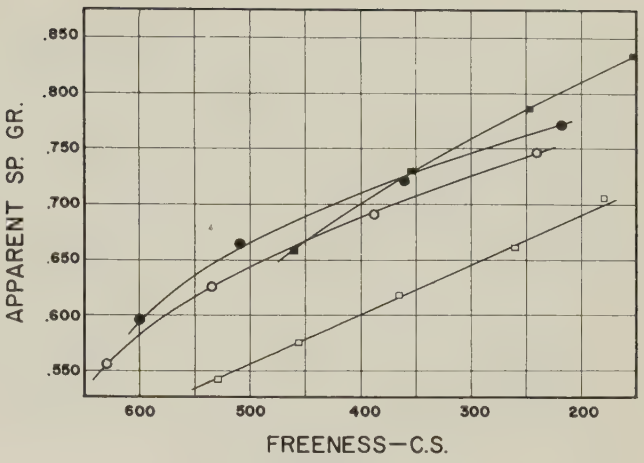

Fig. 3

freenesses of the NSSC pulps. Because of the mechanical defiberizing step in the NSSC process, it is not surprising that the initial freeness of the unbleached NSSC should be 40 points less than the initial freeness of the unbleached kraft. It is not readily explainable why the freeness of kraft drops only 10 points on bleaching while the NSSC freeness drops 60 points. We have made attempts to use the fiber length index and various other measures of fiber length to study the bleaching of these two pulps. It does not appear from the data that

Table II

Pulp	*Viscosity (3) cp.*	*Initial C.S. freeness, ml.*	*Average fiber length, mm.*	*Zero span tensile, g.*
Unbl. kraft	..	635	1.08	29.9 ± 0.7
Bl. kraft	15.0	625	1.11	25.2 ± 0.7
Unbl. NSSC	..	595	1.12	29.0 ± 0.7
Bl. NSSC	20.2	535	1.14	29.7 ± 0.7

this drop in freeness can be attributed to a change in average fiber length. It is well known that bleached NSSC pulp is a more "easy beating" pulp than kraft and perhaps just the handling that it gets in being processed through a bleach plant is enough to reduce its freeness by this amount. One other interesting difference is that the viscosity of the bleached NSSC pulp is higher than the viscosity of the bleached kraft.

It is also of interest to note that the zero span tensile strength of kraft pulp decreases on bleaching while the zero span tensile of NSSC does not change significantly

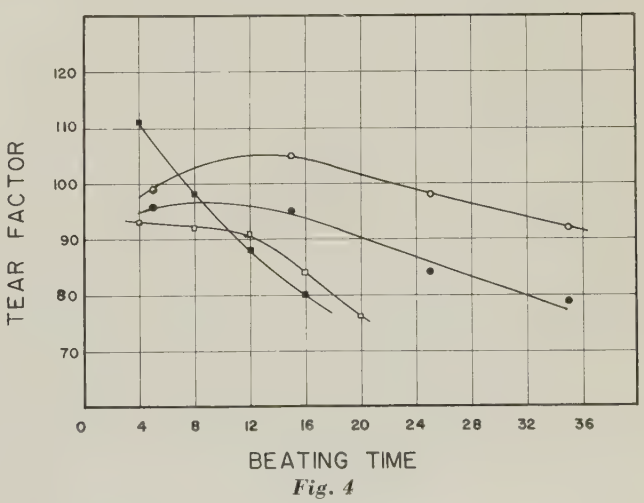

Fig. 4

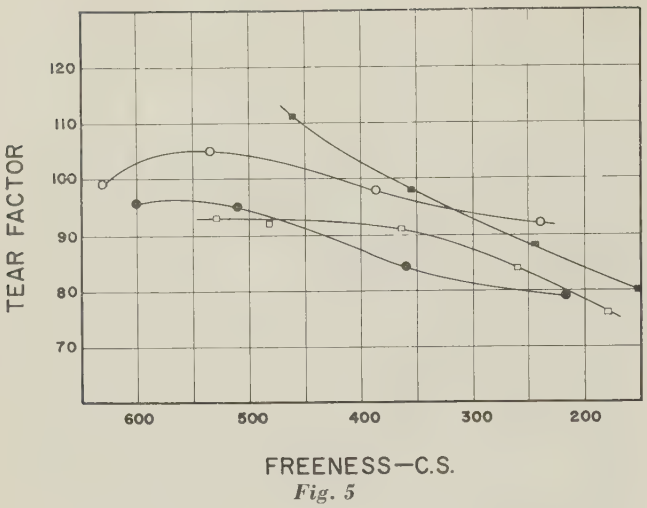

Fig. 5

on bleaching. In fact, there is no significant difference in the zero span tensile strengths of unbleached kraft, unbleached or bleached NSSC pulp. Only the bleached kraft has a lower zero span tensile.

The strength properties of the pulps, as determined

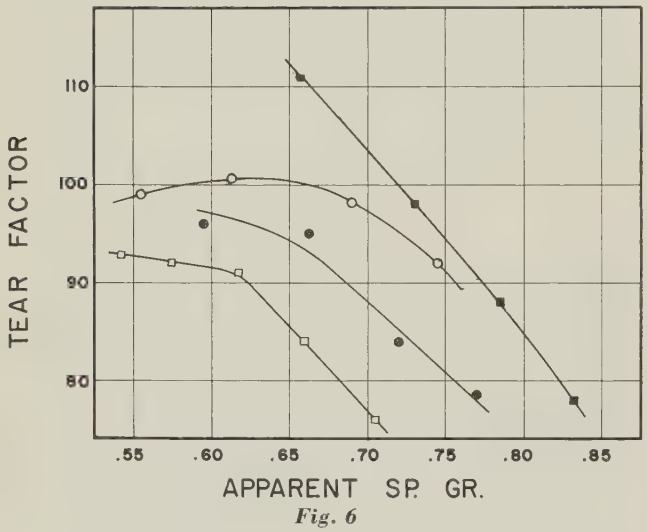

Fig. 6

by the TAPPI Valley beater method, are given in Table III. These values are the averages of from six to nine different samples of pulp taken over a period of several months. The graph of freeness against beating time, as shown in Fig. 1, illustrates clearly the difference in ease

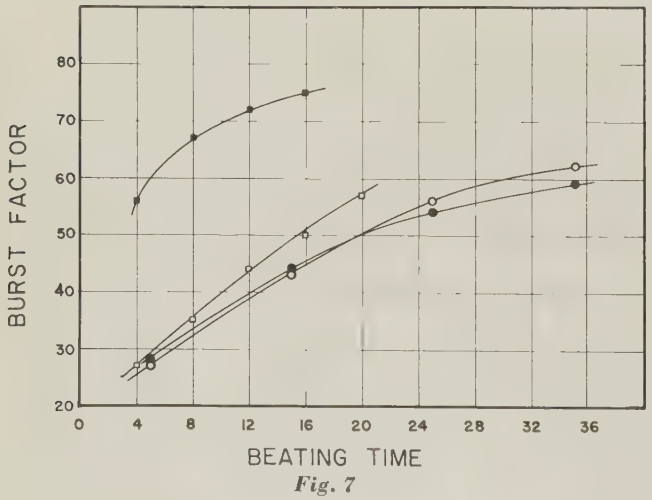

Fig. 7

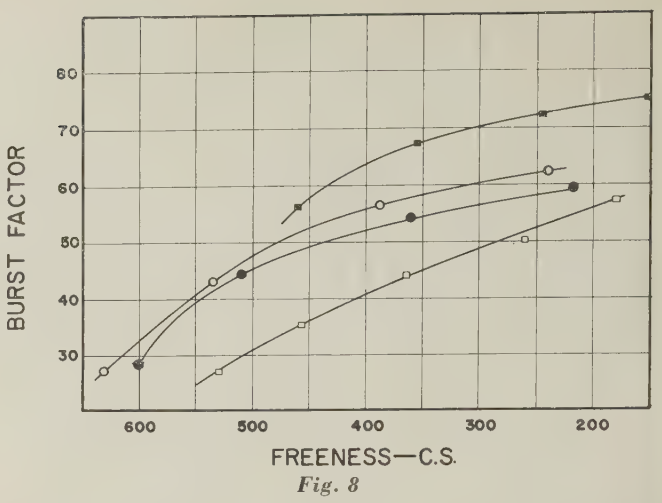

Fig. 8

of refining of the two pulps. The rate of beating NSSC pulp is approximately twice the rate for kraft pulp. As has been pointed out earlier, the unbleached pulps in both instances have the highest initial freeness.

The graphs of apparent specific gravity against beat-

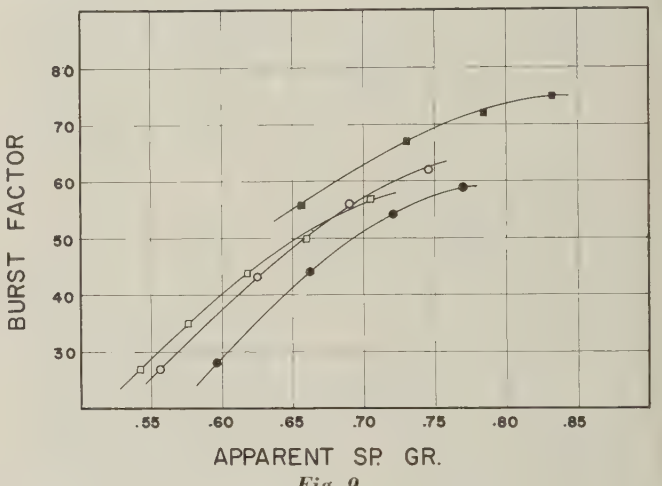

Fig. 9

ing time and freeness, Figs. 2 and 3, show some interesting relationships. The graphs of specific gravity versus beating time show that the apparent specific gravity or weight of pulp per unit sheet volume initially is approximately the same for the unbleached kraft and un-

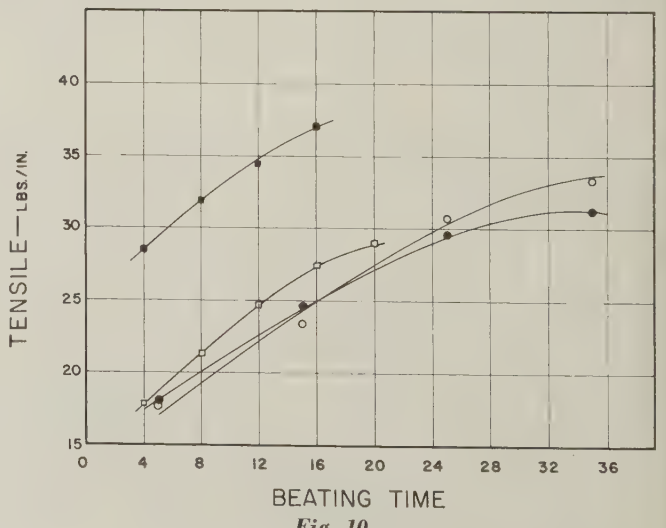

Fig. 10

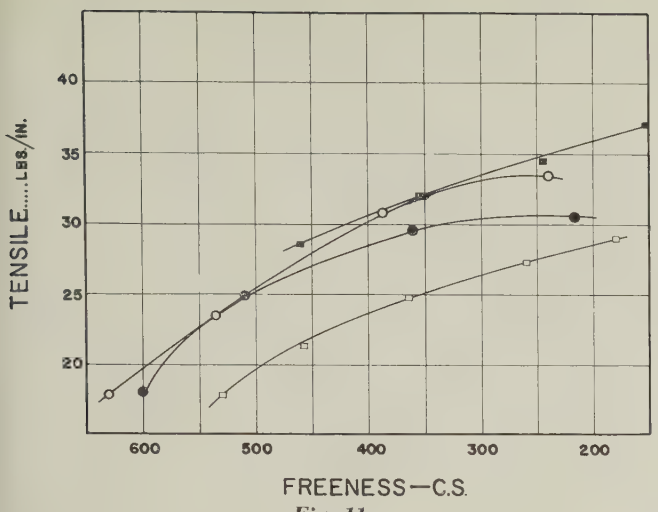

Fig. 11

bleached NSSC pulp. The specific gravity of the NSSC pulp increases more rapidly with beating time than does the specific gravity of the kraft pulp. When apparent

Table III

Beating time, min.	*C.S. freeness, ml.*	*Apparent sp. gr. g./cc.*	*Burst factor*	*Tear factor*	*Tensile, lb./in.*	*Burst factor tear factor ratio*
			Unbleached Kraft			
5	630	0.556	27	99	18	0.275
15	534	0.625	43	105	23	0.410
25	388	0.690	56	98	31	0.570
35	240	0.745	62	92	33	0.675
			Bleached Kraft			
5	600	0.596	28	96	18	0.290
15	509	0.662	44	95	25	0.465
25	359	0.720	54	84	30	0.640
35	218	0.771	59	79	30	0.750
			Unbleached NSSC			
4	530	0.543	27	93	18	0.290
8	457	0.576	35	92	21	0.380
12	366	0.618	44	91	25	0.485
16	259	0.661	50	84	27	0.595
20	179	0.705	57	76	29	0.750
			Bleached NSSC			
4	460	0.657	56	111	29	0.505
8	356	0.729	67	98	32	0.685
12	245	0.784	72	88	35	0.820
16	152	0.832	75	80	37	0.940

specific gravity is plotted against freeness, an entirely different picture is obtained. At any given freeness the apparent specific gravity of bleached NSSC pulp is not

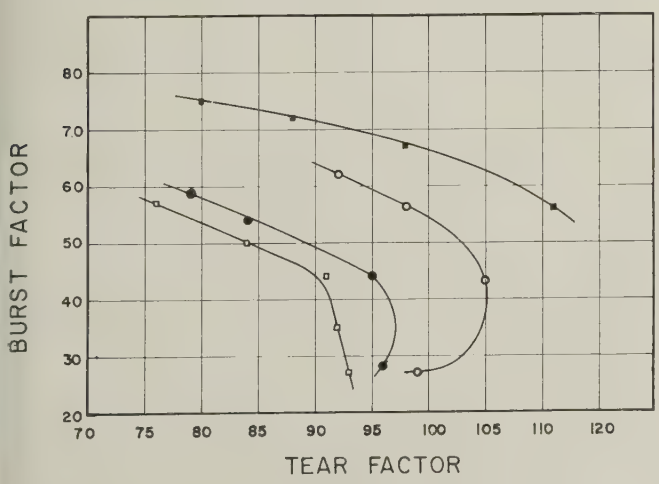

Fig. 12

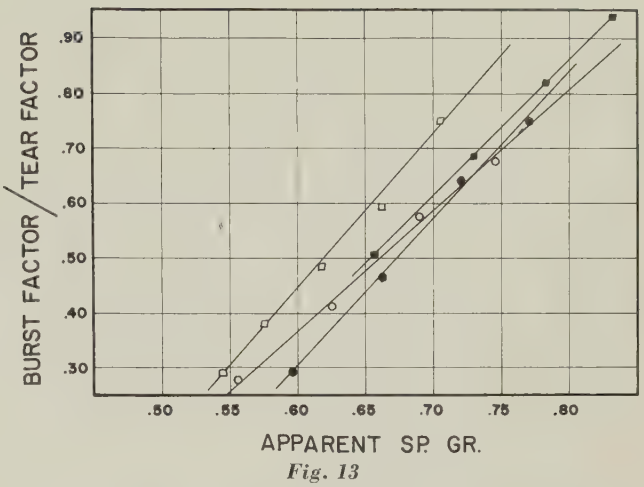

Fig. 13

greatly different from that of bleached or unbleached kraft pulps. In this case, only the unbleached NSSC pulp is greatly different from the others in its characteristics. It has a low apparent specific gravity at any freeness than the other pulps. These peculiar characteristics of the unbleached and bleached NSSC pulps have a great influence on their strength properties. When comparing the two pulps it is important to know whether they are being compared on the basis of beating time, freeness or sheet density.

Graphs of tear factor versus beating time, freeness and apparent specific gravity, Figs. 4, 5, and 6, show marked differences between the kraft and NSSC pulp. At any given beating time, freeness, or specific gravity, the tear of the unbleached kraft pulp is higher than the bleached kraft pulp. At any given freeness or any sheet density, the tear of the bleached NSSC pulp is greater than the unbleached. However, this relationship does not hold true with beating time since the bleached NSSC pulp beats so much easier than any of the others the tear factor drops off more rapidly. In fact, when plotted against beating time, it gives an entirely different curve than do any of the other pulps. The NSSC pulp has an initially higher tear than any of the other pulps, but on beating it falls off more rapidly than the other pulps. Tear of the unbleached kraft pulp increases on initial beating and gradually decreases. Its rate of change with beating, freeness, or specific gravity is smaller than all of the other pulps.

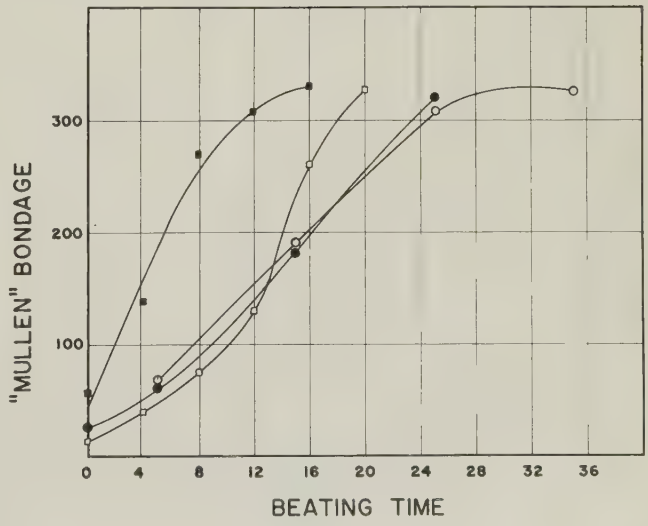

Fig. 14

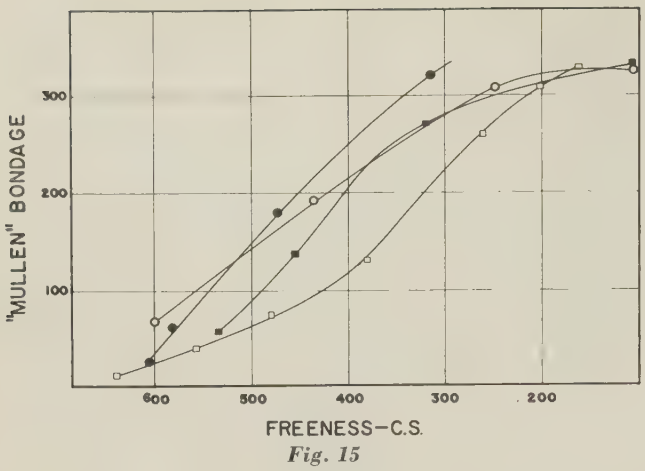

Fig. 15

The burst factor, Figs. 7, 8, and 9, show the most consistent relationship between the pulps. In every case the burst factor of the bleached NSSC pulp is appreciably higher than for any of the other three pulps. The burst factor again shows the marked differences which take place in the two pulps on bleaching. The burst factor of bleached kraft pulp is slightly less than the unbleached when plotted against beating time, freeness or density. The burst factor of bleached NSSC pulp is always appreciably greater than the unbleached. In fact, in some cases the burst factor of bleached NSSC pulp is almost double that of unbleached NSSC pulp. As will be seen in Figs. 10 and 11, tensile strength shows the same general characteristics as does the burst factor.

One of the means we have found useful for characterizing a pulp is to plot its bursting strength against its tearing strength. It is known that in general, as a pulp is beaten its burst strength increases as its tearing strength decreases. The value of the burst factor at any given tear factor, then, is an important characteristic. The plot of the burst factor against the tear factor for the four pulps in this study is shown in Fig. 12. When kraft pulp is bleached its strength characteristics are appreciably decreased. It has the lowest bursting strength at any given tear value. However, when NSSC pulp is bleached its strength characteristics are appreciably increased. For example, at a tear factor of 92, the burst factors for the four pulps are as follows:

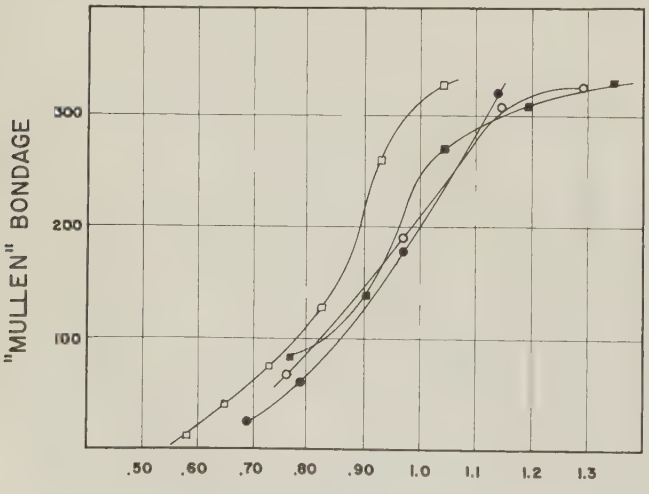

Fig. 16

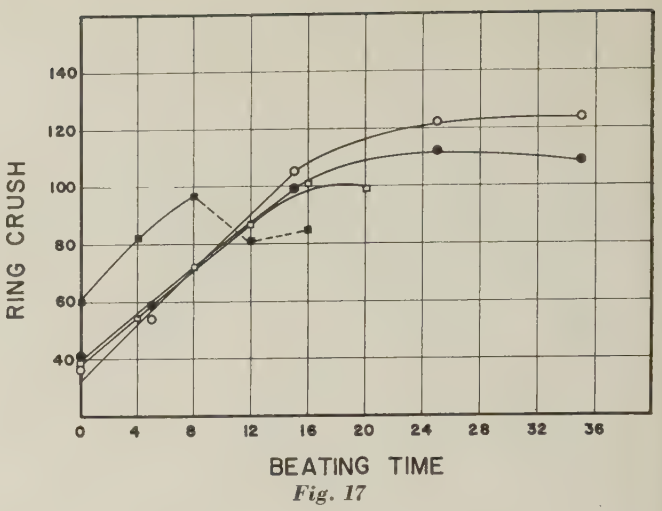

Fig. 17

unbleached NSSC—35, bleached kraft—47, unbleached kraft—62, bleached NSSC—71. Another value which we have used to characterize pulps is the burst factor-tear factor ratio. When this ratio is plotted against the apparent specific gravity a straight line results. The graphs for the four pulps used in this study are shown in Fig. 13. From these graphs it will be noted that the slope of the curves or the rate of the change of the burst factor-tear factor ratio with apparent specific gravity is essentially the same for all of the pulps.

In order to study some of the properties of the pulp which are of particular interest in the manufacture of paperboard, three-ply handsheets were made. The technique used in this study is to couch the first sheet off the sheet mold in the normal manner and then to couch the second sheet off on the first and the third off on the first and second. These are then pressed and dried on metal plates. The data obtained from these multiply handsheets are given in Table IV. The bondage (*4*, *5*) developed in the handsheets is shown graphically in Figs. 14, 15, and 16. These graphs show that for a given amount of refining the bondages of the bleached NSSC pulps are superior, however, for a given freeness or a given sheet density bondages of the bleached NSSC are quite similar to both the bleached and unbleached kraft.

The values for ring crush are shown graphically in Figs. 17, 18, and 19. These data show essentially the same thing as is shown by bondage. The ring crush value of the bleached NSSC starts higher and increases more rapidly than the other pulps up to 8 min. beating time. At any given freeness, however, the kraft pulps exhibit a higher ring crush value than the NSSC pulps.

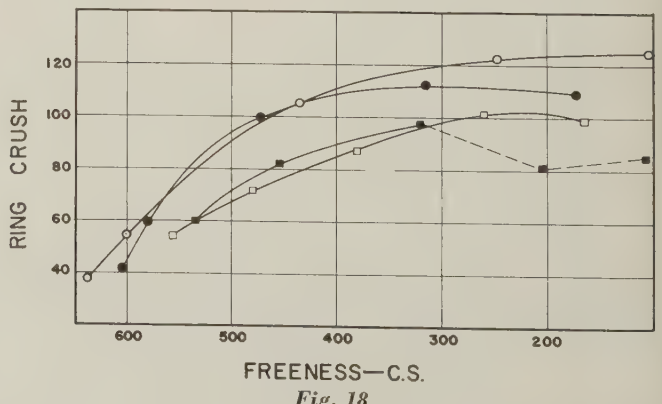

Fig. 18

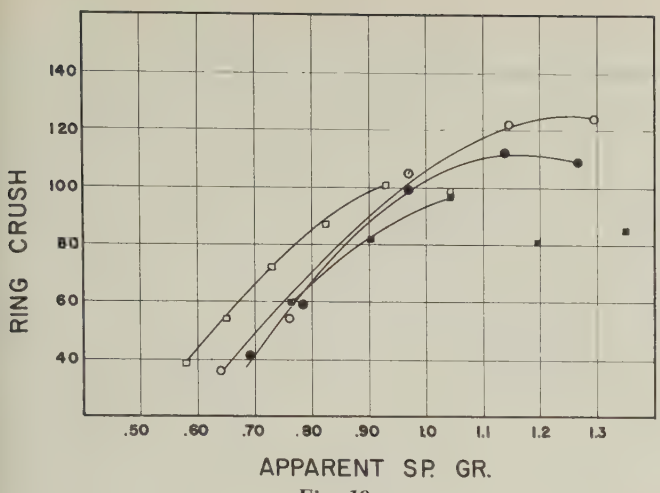

Fig. 19

Table IV

Beating time, min.	*C.S. freeness, ml.*	*App. sp. gr.*	*Ring crush*	*"Mullen" bondage*	*Taber rigidity factor*
		Unbleached Kraft			
0	637	0.639	36	..	0.090
5	600	0.758	54	68	0.119
15	435	0.971	105	191	0.201
25	248	1.147	122	308	0.283
35	106	1.295	124	325	0.321
		Bleached Kraft			
0	605	0.691	41	24	0.098
5	581	0.783	59	61	0.127
15	472	0.968	99	181	0.194
25	316	1.142	112	320	0.254
35	172	1.264	109	378	0.288
		Unbleached NSSC			
0	641	0.582	38	12	0.077
4	558	0.650	54	39	0.093
8	480	0.729	72	76	0.114
12	380	0.826	87	129	0.151
16	261	0.929	101	261	0.195
20	166	1.043	99	328	0.251
		Bleached NSSC			
0	535	0.763	60	58	0.127
4	456	0.903	82	137	0.198
8	321	1.047	97	270	0.247
12	203	1.196	81	307	0.305
16	108	1.351	85	329	0.360

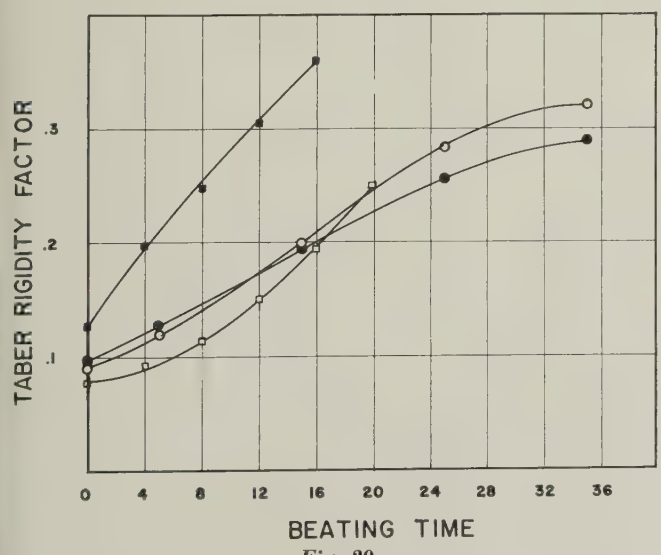

Fig. 20

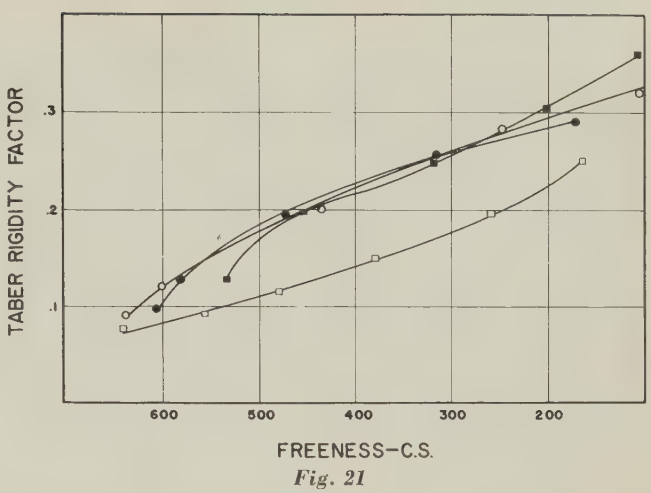

Fig. 21

There is very little difference between the bleached and the unbleached in either case. At any given sheet density all of the pulps are quite similar. The unbleached NSSC does have a slightly higher ring crush than the other three.

Figures 20, 21, and 22 show the Taber rigidity factor. This is the Taber stiffness times the weight divided by the caliper cubed. It is analogous to the TAPPI rigidity factor except that a Taber stiffness tester is used. These graphs show that, at any given density or apparent specific gravity, the stiffness or rigidity of the four pulps are all the same.

Using a method developed by The Institute of Paper Chemistry, Appleton, Wis., (*6*) the relative bonded area was determined on the single-ply handsheets. This relative bonded area is calculated from measured specific light scattering coefficient values. Graphs of tensile versus specific scattering coefficient are shown in Figs. 23 and 24. From these data the graphs of relative bonded area versus tensile for the bleached pulps are given, Fig. 25. It will be noted that for a given relative bonded area the tensile of the bleached NSSC is greater than the tensile of bleached kraft. This is in line with the finding that the bleached kraft has the lower zero span tensile strength.

In another study the relative bonded area of bleached kraft and NSSC pulps have been compared to the apparent specific gravity of the handsheets made during a Valley beater test. It was found that a good correla-

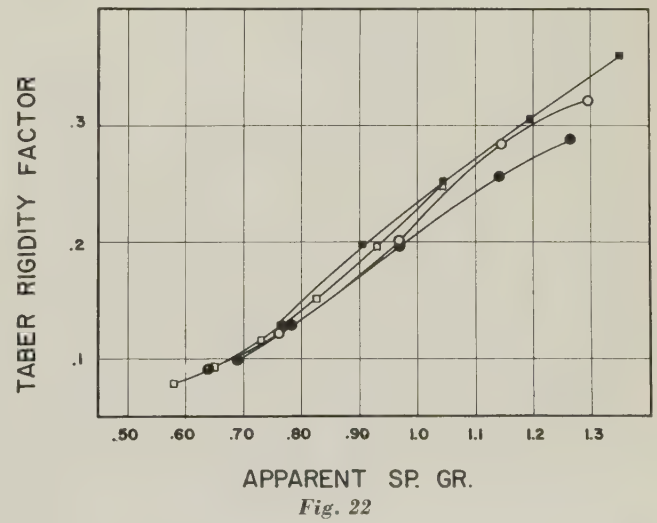

Fig. 22

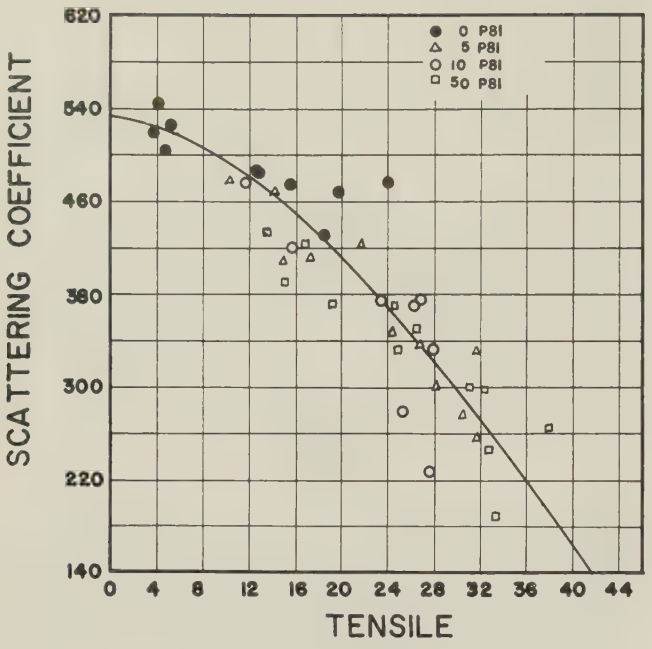

Fig. 23. Bleached Kraft

tion does exist between the relative bonded area and the density of the handsheets. This is shown in Fig. 26. The calculated correlation coefficient is 0.97 in both cases. It is not surprising that a relationship exists between relative bonded area and sheet density. It would be expected that, as the number of fibers per unit volume is increased, the relative bonded area would increase. It is of interest that a direct straight line relationship exists and that the correlation is so good. Thus, when any strength characteristic shows a straight line relationship when plotted against apparent specific gravity a straight line relationship between the characteristic and relative bonded area is indicated. From the data in this study we would conclude that for both bleached kraft and NSSC pulps the Taber rigidity factor is a direct function of the number of fiber to fiber bonds. The ring crush increases as the fiber to fiber bonds in-

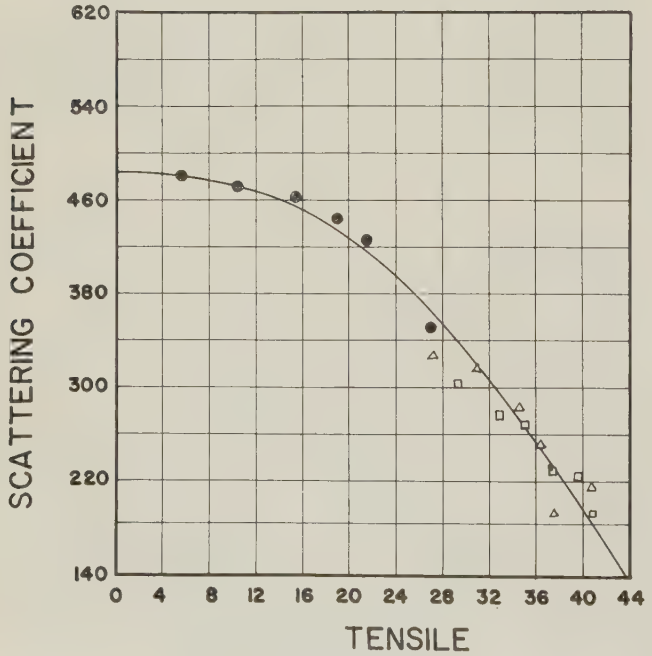

Fig. 24. Bleached NSSC

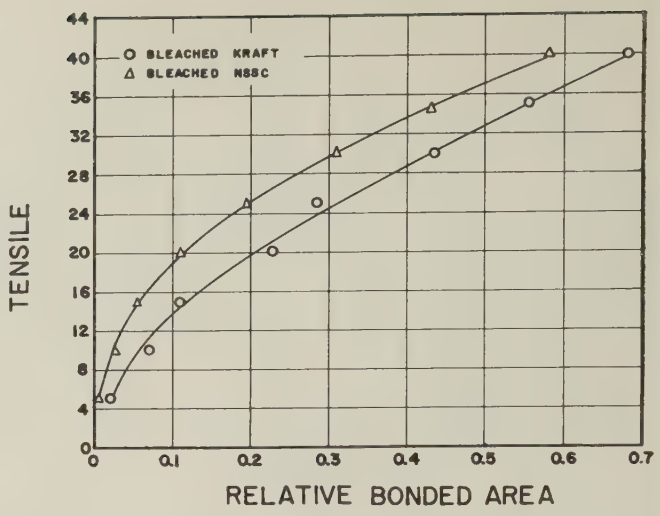

Fig. 25

crease up to some critical point, then the values either drop or level off.

From Fig. 26, it is seen that for any given sheet density the relative bonded area is higher for bleached NSSC pulp than for bleached kraft. Thus, it is seen that the higher strength properties of NSSC pulp can be explained by the fact that it has a higher zero span tensile and a higher relative bonded area. Attempts to determine relative bonded area of the unbleached pulps were not successful.

No attempt has been made in this study to correlate the laboratory strength tests to the strength tests of machine made paper. In general, however, it can be said that in only two properties is there any apparent question about there being a good correlation. These are rigidity or stiffness and ring crush. Because of the variables in refining and papermaking there is a question about whether the relationships shown between the stiffness and ring crush of the pulps in the laboratory will hold true with board made on a cylinder machine. More research on this phase of the subject will be required.

CONCLUSIONS

In summary it appears that the most characteristic

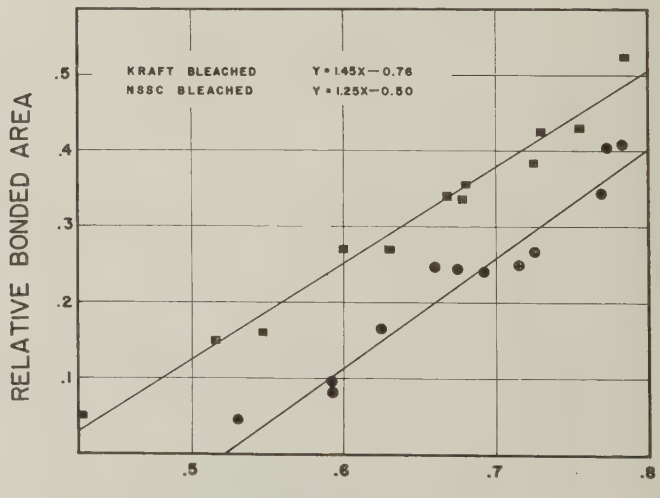

Fig. 26

differences in hardwood pulps produced by the kraft and NSSC processes are:

1. As indicated by the zero span tensile test, the inherent tensile strength of the unbleached fibers are the same but on bleaching the kraft pulp loses tensile strength while the NSSC pulp does not.
2. Bleached NSSC pulps requires appreciably less refining than any of the other pulps to develop its maximum strength characteristics.
3. At any specific freeness or sheet density the burst, tensile and tear values of the bleached NSSC pulp are higher than for the other three pulps.
4. Unbleached kraft pulp is stronger than unbleached NSSC pulp.

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A Wide Range Pressure Inlet: Design and Operation

NICOLAS M. REITZEL

The problem of design and operation of a stock inlet for a speed range of 500 to 2000 f.p.m. and a wide variety of fine paper grades is presented. It was decided that existing commercial designs of stock inlets were not wholly satisfactory for the operation. The basis of a satisfactory design, including a nonsymmetrical distributor and a pressurized full-running stock nozzle type of inlet are discussed with respect to sheet uniformity, formation, cleanliness, and other operating factors. The operating results of a year of production are presented. Good sheet uniformity and formation are indicated, although the operation is adversely affected by cleanliness of the inlet. Current work to improve the cleanliness is described and it is indicated that substantial improvement is possible, leading to a unit that meets the original problem in a satisfactory fashion.

THREE years years ago a group of men, representing one of the leading fine paper manufacturers of the United States, and the Rice Barton Corp., met to discuss a paper machine that in its final form represented a substantial departure from the machines conventionally employed in the fine paper industry. As ultimately conceived, this machine was planned to take advantage of recent developments in paper manufacture to permit an operating range covering the manufacture of papers from 150 lb. per 3000 sq. ft. at 500 f.p.m. to 30 lb. per 3000 sq. ft. at speeds up to 2000 f.p.m., the weight at the high speed being imposed basically by the economical investment in drier capacity. The grades to be manufactured were principally bond and printing papers containing varying proportions of soft and hardwood fibers with ash values up to 20%.

One of the most difficult problems involved was in the selection of a suitable stock inlet for this machine. It was necessary to provide a unit which could satisfactorily deliver the formation and uniformity required in the sheet of paper at heads varying from 1 to 16 ft. of water at the slice and at total stock flows varying from 4000 to 12,000 g.p.m. Simultaneously, the problems of cleanliness and dispersion of the particularly difficult stocks used in the fine paper industry had to be overcome through this wide range. A major problem confronting the high speed manufacture of fine papers, in common with the manufacture of newsprint and kraft, has been the maintenance of uniformity of basis weight and proper formation with increasing speed. It was considered necessary to pay particular attention to these factors in the selection of an inlet for this machine. In addition it was felt that the operation and adjustment of the inlet could be substantially simplified. This discussion is principally concerned with the development of a suitable inlet for this paper machine and the operating results achieved in the final design.

NICOLAS M. REITZEL, Project Engineer, Rice Barton Corp., Worcester, Mass.

HEADBOX FUNCTIONS

Before going further into a discussion of the inlet it would be wise to establish a common ground for discussion. A definition of stock inlet functions by Mardon (*1*) may be expanded.

A stock inlet may be broken into three essential parts: the distributor, the headbox, and the slice. The function of the distributor is essentially to take a flow of paper stock from a single pipe or a number of pipes and to deliver it in the general direction of the machine in a uniform flow spread across the width of the machine. The function of the headbox is to provide sufficient head, either hydraulic or pneumatic, to the stock to develop through the slice a jet velocity approximately equal to the speed of the machine. A secondary but vital function of the headbox is to further distribute the stock and overcome defects in the operation of the distributor. The purpose of the slice is to deliver to the wire of the paper machine a jet of the correct velocity and direction to permit the laying down of a uniform and properly formed sheet of paper. The essentially complex hydraulic operations must be performed with arrangements that can handle paper stock, in itself a complex material of highly variable properties, without producing any effects detrimental to the objectives previously mentioned. Paper stock may consist of several different types of fibers of varying length and character plus additives, such as substantial amounts of

clay or pigment, and flocculating agents, such as glue or alum. Flow must take place through the inlet with a minimum tendency to deposit components of the stock on any part of the inlet and in a proper state of agitation to prevent flocculation or settling of the various components of the stock. The problem is further confounded by the tendency of paper stock to pick up large amounts of air which are frequently released in undesirable quantities in certain portions of the inlet.

It is a well known fact to any papermaker that the ideal device for accomplishing the above functions has not yet been developed. That this is so is indicated by the great number of inlet designs that have been developed in the history of papermaking and the concentrated efforts currently being expended by machinery builders and paper mills in the search for suitable equipment. Many good headboxes exist. In fact any machine that is making commercially acceptable paper has, at the least, a headbox that is satisfactory for its particular operating conditions. However, most existing headboxes have defects which are more or less significant, in some cases limiting the quality or maximum speed attainable by a given paper machine.

DISTRIBUTION

The distributors of most headboxes are a major source of difficulty. Depending on the design, two major problems may arise. In the case where flows are from the side of the machine and the stock is required to change its direction of flow 90° to proceed in the machine direction, substantial crossflows appear in the headbox itself and are frequently very difficult to eliminate before the slice is reached. Another type of distributor involves the use of a relatively small number of pipes entering the back of the headbox. The flow from these individual pipes must spread and be made uniform in the headbox, and insufficient headbox volume will frequently result in a condition of spearheading on the wire of the paper machine with consequent steaks of nonuniform basis weight. In addition, the distribution of stock through a number of individual pipes is usually both nonuniform and unstable. It is to be observed that most distributor designs in the past have been symmetrical in nature, i.e., the piping is arranged identically about the centerline of the machine. Although this would seem a logical start toward uniform distribution, in fact it is most difficult to split a hydraulic stream into equal portions in a stable fashion. A distributor of the crossflow type or the multiple pipe type conventionally employed must have at least one such split of the total flow, and the resultant flows tend to be unequal and fluctuating in an uncontrollable fashion, despite extreme care in making the splitting device physically symmetrical. The instability is a function of the inherently turbulent nature of the flow at the flow splitter and can be eliminated only by the introduction of large amounts of resistance in the two lines following the split. It is usually not feasible to provide the large resistance required within pipe lines, and as a result the symmetrical type of distributor, in order to deliver a uniform flow to the headbox itself, must be of complex construction and substantial dimensions.

HEADBOX

Any nonuniformities and instabilities in the flow coming from the distributor to the headbox must be eliminated by the headbox so that delivery to the slice will be uniform. Essentially, the headbox must contain sufficient resistance, as reflected in hydraulic head loss, to dampen the various defects such as spearheading or crossflows occurring in the delivery from the distributor. Nonuniform flow from the distributor must be equalized, resulting in crossflows in the headbox. These crossflows in turn produce large-scale turbulence within the headbox itself. Turbulence or instability in the flow from the distributor appears as flows varying in time and direction at any fixed point in the inlet and produces effects similar to the turbulence developed by crossflows. In other words, the distributor nonuniformities and fluctuations appear in the headbox as large-scale turbulence, and this large-scale turbulence must be dampened or reduced in scale to very small values prior to the slice. The turbulence appears in the vicinity of the slice as variations in velocity or pressure, which are additive to the average static head developed on the stock at the slice. Thus, any turbulence which is not eliminated by the time the stock flow reaches the slice will result in a jet velocity varying in time at the slice with a corresponding variation in the basis weight of the sheet manufactured.

Conventionally, the operation of eliminating the turbulence is performed, particularly in open inlets, by flowing the stock above and below a number of baffles so that the total flow path of the stock will be many feet in length, and the direction of flow will be reversed in a turbulent manner with resulting head loss. This is effective to a greater or lesser degree in providing a suitable delivery to the slice. However, at best it requires a large headbox volume as the damping of turbulence can result only from the dissipation of energy by fluid friction. To assist this function it has been found that distributor rolls are helpful. However, most distributor rolls built to date have had relatively large holes and high open areas, and are thus incapable of producing appreciable head loss. In addition to the above function an open inlet, i.e., one with the liquid surface bounded by the atmosphere, must also provide enough head of stock to develop the necessary jet velocity. Although effective designs have been worked out for relatively narrow speed ranges, it is most difficult to develop a design that does not require substantial compromises in flow conditions for the heads involved in our problem, i.e., 1 to 16 ft. In addition, the structure of an inlet suitable for 16 ft. of head would be exceedingly large and would require a great deal of head room above the wire.

Some years ago this difficulty was effectively eliminated by the air dome type of inlet in which the atmospheric air boundary is replaced by air at pressures above atmospheric. By varying the air pressure, the head at the slice can be varied over wide ranges, although the liquid level is maintained constant. This type of box, in its most popular form, consists usually of a horizontal flow channel the width of the machine and several feet in depth extending perhaps 6 or 8 ft. from the distributor entrance to the slice and bounded above by air. Distributor rolls are installed in the flow

channel to provide increased head loss and to prevent flocculation and setting.

The operation of distributor rolls in an air-bounded channel poses a dilemma. For the roll to be effective either as flow evener or to prevent flocculation, it must develop turbulence. This in turn requires head loss, resulting in a drop in stock level in passing through the roll. The stock level is usually maintained so that the roll is just covered, implying a relatively small head loss, as an uncovered roll tends to agitate the stock surface, generating large amounts of foam. A roll designed for a particular flow may be satisfactory. However, a substantial increase in flow will produce a corresponding increase in head loss, which will uncover the downstream side. If the stock level is maintained, to keep the roll covered, the greater part of the increased flow will by-pass above the roll, making it ineffective. It is not possible to produce substantial head loss through a roll unless it is bounded by walls that prevent by-passing of the flow. It should be noted that this type of inlet usually contains rolls in the vicinity of the slice and distributor that are so bounded. It is likely that these rolls contribute the bulk of the flow evening in the headbox, while the intermediate rolls are relatively ineffective.

Even with rolls agitating the open channel, difficulty has been experienced with the setting of components of the stock, particularly clay fillers and pigments common with some papers, and caution must be used in applying this type of inlet to these stocks.

SLICE

The function of the slice is to take the stock delivered by the headbox at high static head and low velocity, accelerate this stock, and deliver it to the atmosphere at high velocity. The delivery to the wire must be made in the right direction, uniform with respect to time and across the machine, and with the correct degree of turbulence in order to achieve proper formation of the sheet. The slice cannot function without good delivery from the box, as errors in delivery will appear as errors in velocity in the jet. The slice must provide considerable adjustability. A gross adjustment extending across the machine for the width of the opening is necessary to permit the balancing of jet velocity and stock quantity. In addition, adjustment of the opening must frequently be performed in localized areas to correct for both headbox defects and nonuniformities in the performance of the paper machine on the fourdrinier and in other parts. A ruggedly constructed and mechanically stable slice will function properly in most respects, and there are relatively few bad slices on modern paper machines. One thing that is lacking on most slices, however, is the opportunity for simple adjustment of the relative locations of upper and lower slice lip and the breast roll of the fourdrinier. It is surprising the effect that adjustment of these conditions can have on the formation of the sheet of paper, and it is believed that, considering the unpredictable nature of the formation of a sheet of paper, most papermakers would greatly appreciate the opportunity to vary these conditions while the machine is in operation, so that the effect of such adjustments could be immediately observed. However, the mechanical complications involved in such an arrangement have made it uneconomical to provide for these adjustments, except to a limited and unsatisfactory degree, and the papermaker is forced to do his best without their assistance.

CLEANLINESS

An essential consideration of good headbox design is the problem of cleanliness. The nature of paper stock is such that, for a number of reasons including growth of microorganisms, the use of sticky additives and the tendency of paper fibers to tangle with one another, various types of deposits occur on the internal surfaces of virtually every stock inlet. These deposits are harmful in two ways. Substantial sized strings and lumps of stock constituents will build up on the surface of a headbox. When these lumps reach sufficient size, they are washed off the surface of the inlet by the flow of stock and carried out into the sheet of paper, producing sheet defects. In addition, especially in high speed machines, the build-up of deposits on the interior surfaces of the stock inlet, particularly in the vicinity of the slice, results in changes of the shape of the stock passage. These changes in turn produce turbulence and nonuniform flow at the slice. As their location tends to vary in time they are difficult to compensate for by manipulation of the slice and result in nonuniformities in the finished sheet. In this respect the operation of an inlet requires a design that is inherently free of areas in which stock may gather. The principal defects in inlet design or construction which result in areas where dirt build-up may be excessive are improper surface finishes or materials, improper joints or connections, and areas in which air or foam may collect. The latter is a particularly difficult problem because the presence of air or air-rich foam greatly enhances the growth of bacterial deposits and also, by permitting the stock constituents to dry out, promotes the growth of strings and stock lumps.

Despite good design, no inlet has been built to date which does not require clean-up. The design should, therefore, consider ease of cleaning and accessibility of all portions of the inlet surfaces to permit clean-up when required to be done with a minimum of machine down-time. In this respect the open inlet is unquestionably the best. Air that rises to the top of the stock separates freely and is discharged to the atmosphere. Suitable showering of the air-stock boundaries is of great assistance in keeping these areas free of foam and stock build-up. Further, virtually all surfaces of the inlet are easily made accessible for cleaning through the open top.

The air dome inlet ranks only a little lower, the principal problem being accessibility for wash-up operations due to the closed top. The current trend in air dome boxes toward more streamlined flow passages introduces additional problems, however, as the stock stream is bounded by upper headbox walls in some flow areas. These upper walls in contact with the stock tend to dirty rapidly because foam layers may occur on the upper surface, promoting the development of deposits. In fact, the only headbox walls that will remain free of deposits for substantial periods of time are either vertical or below the stock stream.

In addition, the more streamlined design of box generally requires passages of small dimension, which result in problems of accessibility.

The full-running pressure inlet presents some very difficult problems with respect to cleanliness. Particularly, there is a tendency for air or foam to gather at the high point of the unit and contaminate the upper surfaces, unless provision is made to remove them. The conditions in these areas will be ideal for the growth of slime or other stock deposits. As far as the author knows, all full-running inlets have required some arrangement to remove air and foam from these areas in order to achieve satisfactory operation. Design for accessibility for clean-up can become very difficult due to the small passage areas common with the full-running type of inlet. Considerable ingenuity must be applied to minimize the zones in which foam can gather and to make these zones readily accessible for cleaning.

INLET DESIGN

After considering the principles just discussed, it was decided that no inlet type in operation was entirely satisfactory for the application in question, and a new design which would correct the undesirable features of existing inlets was initiated. As a general design philosophy, it was decided to separate unequivocally the three functions previously described and optimize each function.

It was felt that the distribution function should be as complete as possible within the distributor itself so as to minimize the headbox requirements. In other words, the distributor should deliver the stock to a slot the full width of the paper machine under conditions of uniform flow and low turbulence. In addition, a solution was required that would be independent of the width of the paper machine, i.e., a design that would be applicable to any width of machine in a calculable manner for any expected flow. It is found that many existing distributor types may be very effective for a particular machine width or limited flow range, but quite ineffective when applied to other machine widths or other flow rates, making the design of a given distributor arrangement unreliable when extended to new machines.

The headbox was to be small in volume as compared to existing units since the errors in distribution would be small. In addition, work would be done on the development of distributor rolls and other devices that would create large hydraulic pressure drops in a small volume. The shape of the inlet should be such as to produce high hydraulic stability to prevent the generation of unwanted turbulence in the flow through the headbox.

The slice would be highly adjustable and accurately and ruggedly constructed. Adjustment would be provided for slice opening and fore-and-aft motion of the upper lip. It was decided to control the relationship of the apron and breast roll by moving the breast roll to avoid additional mechanical complications in the headbox structure itself.

SINGLE-ENDED DISTRIBUTOR

The distributor design that was developed is shown schematically in Fig. 1. The nonsymmetrical or single-ended manifold shown was conceived and experimentally verified by Gleb Goumeniouk (*2*). In his work he demonstrated on small models that uniform distributions to a number of pipes could be achieved

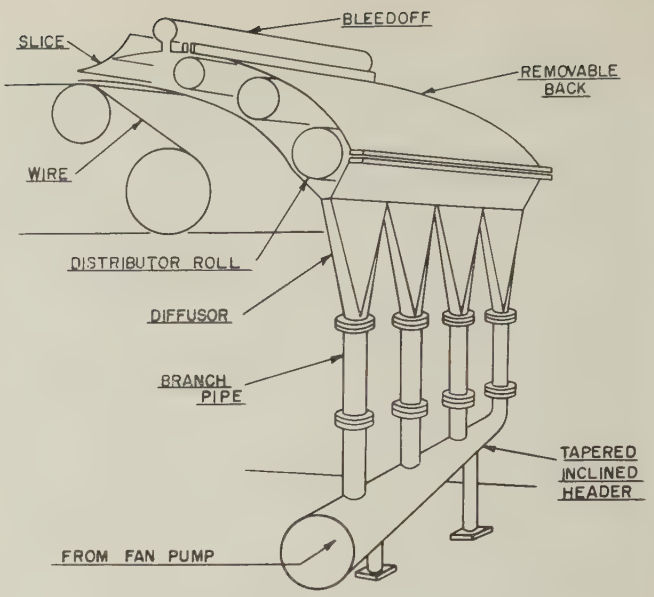

Fig. 1. Distributor and headbox

with this type of construction. The flow in each branch pipe is delivered to the inlet by a diffusor section. The divergence of the diffusor is limited to 12° included angle, this being the angle confirmed experimentally by Van der Meer (*3*) at which separation will not occur along the diverging walls. The flow in the diffusor piece will actually be more stable than a conventional diverging section as the transition is from an 8-in. diam. pipe or 50 sq. in. to a slot 2 by 23 in., or 46 sq. in., and the section of the diffusor in a plane at right angles to the divergence is convergent, the velocity of flow being virtually unchanged through the diffusor. The number of diffusors required for a given width of machine is established by the space available for the diffusor section and the practical limits of fabrication. A diffusor approximately 2 ft. wide must be about 6 ft. long, and this seems to be a convenient dimension. The individual diffusors may be wider or narrower as required to suit a specific machine. A dimension of 20 to 30 in. seems practical. Each diffusor is fed by a branch pipe connected to the single-ended manifold. The manifold is tapered uniformly and the manifold branch pipes and diffusors are sized for a minimum flow of 4 to 5 f.p.s. In the case of this inlet 8-in. diam. branch pipes were required. It should be noted that the header is slanted so that the branch pipes are of unequal length. In order to achieve uniform distribution of flow to each branch pipe, it is necessary that the resistance to flow in every parallel channel be equal. Geometrical arrangement of the manifold and branch pipes is such that working from the delivery end of each branch pipe back to the main pipe connection the theoretical flow resistance through all fittings and pipe is closely equal for each parallel path (Table I). The branch pipes should run at least eight or ten pipe diameters from the manifold to the diffusor pieces. This will effectively dampen any turbulence generated at the points where the branch pipes connect to the manifold, thus allowing the flow to enter the diffusor pieces at the relatively low turbulence level inherent in the branch pipe. This does not impose in most installations any serious space problem as the header may be located near the basement floor and the branch pipes run more or less vertically upward.

Table I. Theoretical Resistance of Distributor Branch Pipes

	Branch no.							
	1	2	3	4	5	6	7	8
Flow in branch, c.f.s.	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Total head loss, ft. H_2O	0.438	0.452	0.456	0.458	0.453	0.437	0.404	0.299

The actual floor area occupied by the distributor may be made quite small if necessary. In addition to the approximately equal resistance of the branch lines and header, the diffusors discharge into a headbox of considerable hydraulic resistance which is uniform across the width of the headbox. This resistance is approximately additive to the resistance of the branch lines and serves further to maintain equal flows through the branch lines. As mentioned above, the entire header system is of approximately uniform cross section so that there is little acceleration or deceleration of the flow through the system. This results in a generally low turbulence throughout the system and prevents the development of undesirably large instabilities which may be delivered to the slice. As seen on the schematic sketch, the individual diffusors are joined at sharp edges, delivering the flow to an open passage the width of the machine. The only nonuniformity that may be expected is a reduction in velocity in a small area adjacent to the junction of two distributors, and the principal function required of the headbox is the elimination of the lower velocity in this limited area. The entire approach piping system from the fan pump to the headbox is directed upwards and a substantial part of the system runs vertically upward. This is done to prevent the development of air pockets or areas in which settling of fillers might occur. An additional feature is incorporated in the manifold to assist in the elimination of air. It was felt that if any substantial amounts of air were entrained in the stock from the fan pump, the free air would migrate to the top of the pipe from the fan pump and the manifold. A slot was provided along the top of the manifold for a distance of about 15 ft. Through this slot a continuous flow of air-rich stock is taken, carrying air out of the system. The branch pipes themselves are connected at the bottom of the header where they draw on a relatively air-lean stock.

Because of the critical nature of the application, and the reasonable assumption that our theoretical calculations would contain some error, a metering and control system was developed to provide an auxiliary means for equalizing the flows in the branch pipes if necessary. This metering system consisted of flow meters in each branch pipe of a type that provided no obstruction to the flow of the stock. Specially designed butterfly valves were installed in each branch line for the purpose of providing additional resistance and thus controlling flow if necessary. The controls were interconnected so as to automatically provide equal flow in the eight lines.

FULL-RUNNING HEADBOX

With the feeling that an adequate distributor had been designed, we were faced with the problem of headbox selection. Three choices were available: the open, the air dome, and the full-pressure type of headbox. Despite the highly successful operation of open headboxes to speeds over 1800 f.p.m., the open type was dropped from consideration because of the large size and limited range of successful designs.

The conventional air dome box was also eliminated because of the wide flow range required and the limited development of resistance possible with distributor rolls in the air-bound region. As mentioned above, this type has also given difficulty with the settling of components of the stock. The remaining type of inlet may be called, for want of a better name, a hydrodynamic inlet. In this type the flow in the inlet is rigorously controlled by the passages forming the inlet structure. Resistance is developed by the installation of distributor rolls which operate to fill the passages completely. Bypassing of the rolls is limited and resistance proportional to flow may be developed. A number of successful inlets embodying such a design in part, but retaining the air dome or air-water boundary have been developed. These inlets function satisfactorily in the regions where flow is full. However, it is difficult to approach the air-bounded zone and leave it without the development of stagnant areas or unwanted instability. This type of inlet, in generalized form, consists of an upward flow passage from the distributor to the air dome and a downward flow passage to the slice. Solid bounded distributor rolls are usually installed in these passages. Although the high point of the inlet, being out of contact with the stock, is relatively free of stock build-up, the bounded flow passages are prone to collect deposits and are difficult to reach for cleaning. Conditions in such passages are, in fact, identical to those occurring in a full-running construction. Because of these difficulties, it was ultimately decided, although it was a difficult choice and involved substantial risk, to concentrate on the development of a full-running inlet and to employ all means available to overcome the difficulties previously mentioned, particularly with respect to air handling and cleanliness.

Figure 1 shows the cross section of the design finally adopted. To make the inlet hydraulically stable, that is, to prevent the development of large-scale turbulence over the width of the machine, it is necessary to provide substantial convergence over the length of the inlet. To achieve this condition, the passage must be opened from the 2 in. wide slot at the distributor to the substantially larger dimension of 10 in. This divergence is accomplished in a very short length by discharging a relatively high velocity jet from the distributor into a high resistance roll. The high resistance roll effectively prevents the development of any large-scale eddies in the divergence.

Figure 2 indicates the flow pattern in the inlet as observed on a full-scale model at maximum flow. It will be seen that a very small eddy, which is stable across the full width of the machine, occurs at the discharge of the distributor. The flow out of the first distributor roll is quite uniform through the depth of the passage and free of large-scale eddies. It is felt that this construction offers advantages over the long

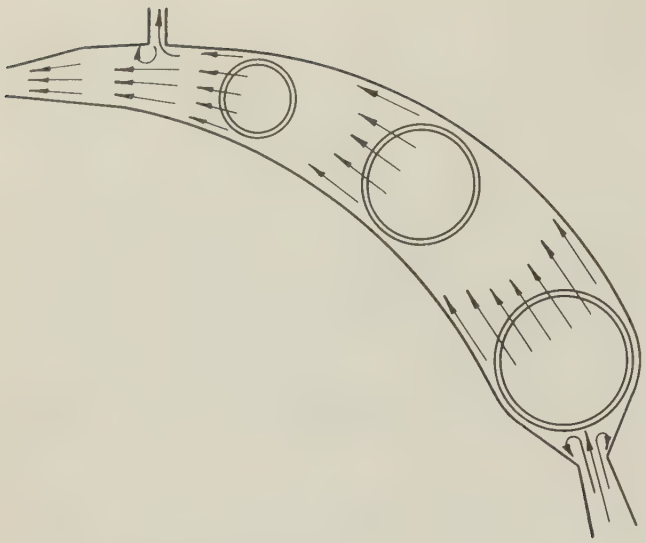

Fig. 2. Inlet flow pattern

divergence used in many inlets, with respect to both mechanical simplicity and hydraulic stability. After leaving the first roll, the passage is convergent to the slice. As previously mentioned, this convergence tends to stabilize the flow and reduce the scale of turbulence as the passage narrows. Two additional distributor rolls assist in this function by providing head loss, and as a secondary function act to maintain the fibers in random orientation and overcome the tendency of the convergent section to line the fibers up in the machine direction, a condition observed by Baines (*4*). By the use of appropriate distributor rolls which are capable of developing large pressure drops, the small errors of distribution previously described can be eliminated in an inlet of very small volume. There is approximately 5 ft. between the distributor and the slice, and this type of inlet may be truly called a stock nozzle. Note also that the uphill flow maintained in the distributor and approach piping is carried virtually to the slice and apron, the purpose being as before to prevent the formation of air pockets and the settling of the constituents of the paper stock.

In the preliminary stages of design a model was built of the inlet. This model was constructed to full size in cross section and 10 in. wide. It was made from Plexiglass so that observations might be made of the behavior of stock within the model. The observations made on such a model must be interpreted with the greatest of care in extending them to a full-sized unit, and we were forced to limit our conclusions to those factors which presupposed a satisfactory delivery from the distributor. The model was used specifically to check the behavior of the divergent entrance to the inlet, the resistance of the rolls expressed as head loss, the behavior of free air, and the cleanliness of the rolls when operated with the typical paper stocks anticipated in the final machine.

A number of roll arrangements were tried, the objective being to find rolls that would produce maximum pressure drop commensurate with satisfactory cleanliness. The roll initially selected for the upper position was a 6-in. perforated roll of $^3/_8$ in. wall thickness and approximately 43% open area. This roll was drilled with $^1/_2$-in. diam. holes arranged on a 60° staggered pattern. The land dimension is large enough ($^1/_4$ in.) to prevent the stapling of the longest fiber stock anticipated. Every effort was made to provide radii at the entrance and exit of the inside and outside surfaces of the roll at each hole.

The other two rolls were initially conceived as bar rolls, constructed with a central shaft bearing disks spaced 1 in. apart, and these disks in turn carrying 1-in. diam. bars spaced to form a $^1/_4$ by 1-in. opening between bars, resulting in 20% open area. Although it is not recommended that such a roll be installed immediately adjacent to the slice, because of its tendency to mark the sheet, it seemed a very satisfactory design for the other rolls, as the streamlined passages should permit the construction of a very clean distributor roll without being involved in complicated finishing operations. It is felt unnecessary to operate the rolls in close contact with the inlet walls as a stock flow through a substantial gap will be very similar to that through the openings in the roll. If this gap is large, the relative variation in opening is small for a given change in dimension of the roll or wall. A dimension of $^1/_4$-in. was considered reasonable. This relatively large value permits practical variations in wall and roll dimensions without producing substantial variations in flow along the walls across the machine. It was observed in the model that the flows along the walls were slightly higher than the flow through the roll itself, and it is felt that these slightly higher flows are beneficial in maintaining the state of cleanliness of the walls of the inlet. Despite the relatively large clearances between the rolls and the inlet walls, the resistances of the rolls remain high. The head losses tabulated in Table II indicate the results determined from the model.

Two additional features of the inlet deserve comment. Across the machine at the high point of the headbox between the 6-in. diam. roll and the slice, a continuous 1-in. wide slot is cut in the upper skin of the inlet. Most free air carried in the system will migrate to this point by virtue of the upward slope of the distributor and headbox and an upward slope from the slice. An air-rich stock stream is removed from the inlet at this point to prevent the build-up of air or foam in the highest area, or the discharge of free air at the slice. It was also necessary to provide accessibility for clean-up to the inner surfaces of the inlet. To accomplish this a portion of the upper surface is made removable. The removable area is indicated on Fig. 1. This removable section is flanged at top and bottom and the skin is supported on a ribbed structure which in turn rolls on rails at the side frames. The flanges are detached and this portion of the upper skin rolled back. Under these conditions the three distributor rolls and the upper and lower skins between them are accessible for cleaning. The area between the 6-in. roll and the slice is acces-

Table II. Measured Head Losses of Distributor Rolls

	Roll type				
Flow g.p.m./ in. width	*6-in. perf., $^1/_2$ holes, 43% open, ft. H_2O*	*8$^1/_4$-in. bar, 20% open, ft. H_2O*	*10-in. bar, 20% open, ft. H_2O*	*10-in. diam., $^1/_2$ in. perf., 36% open, ft. H_2O*	*10-in. diam., $^{13}/_{16}$-in. perf., 40% open, ft. H_2O*
25	0.02	0.28	0.26	0.55	0.25
30	0.06	0.36	0.40	0.63	0.43
40	0.30	0.47	0.80	1.08	0.85
50	0.48	0.78	1.37	1.57	1.37

Note. Head losses for 10-in. diam. roll include head loss in divergence. 50 g.p.m./in. corresponds to a total stock flow on the machine of 9000 g.p.m.

sible to cleaning from the slice and the cleaning operation may be assisted by proper showering arrangements and accessories which can be operated from the front of the box.

SLICE DESIGN

The main criteria of slice design were adjustability and rigidity. Based on unhappy experience with some slice designs applied to high speed operation, it was decided that the apron and slice should be of substantial weight and stiffness. In this connection we would digress briefly on the proper operation of the slice. In the interests of sheet uniformity a headbox should deliver the flow to the wire with an essentially level slice setting. It is highly undesirable to warp the slice lip appreciably to overcome headbox or machine defects, as this warping will give rise to instability of the stock on the fourdrinier and the result is a necessary compromise of sheet quality. If suitable conditions can be attained in the headbox and the remainder of the paper machine, the deformation of the slice can be at a minimum. Under these conditions comparatively rigid slice blades may be used, as the only adjustment that should ideally be required is a slight lifting of the slice at the deckles to provide a full flow of paper stock on the edge of the sheet. Successful operation in some recent installations of an apron blade of substantial thickness led us to the design because of its rigidity under the high pressures developed at the maximum machine speed. The apron thickness in the final design is $^{5}/_{16}$-in. and the slice lip thickness $^{3}/_{16}$-in. The slice blade is quite stiff as individual slice adjusting screws are located at 5-in. intervals across the width of the machine. Particular attention was paid to the development of a rugged and precise slice operating mechanism, so that gross adjustments of the slice opening might be made uniform across the width of the machine. This is of considerable operating advantage as it is not necessary to readjust the individual slice screws on changing the total slice opening.

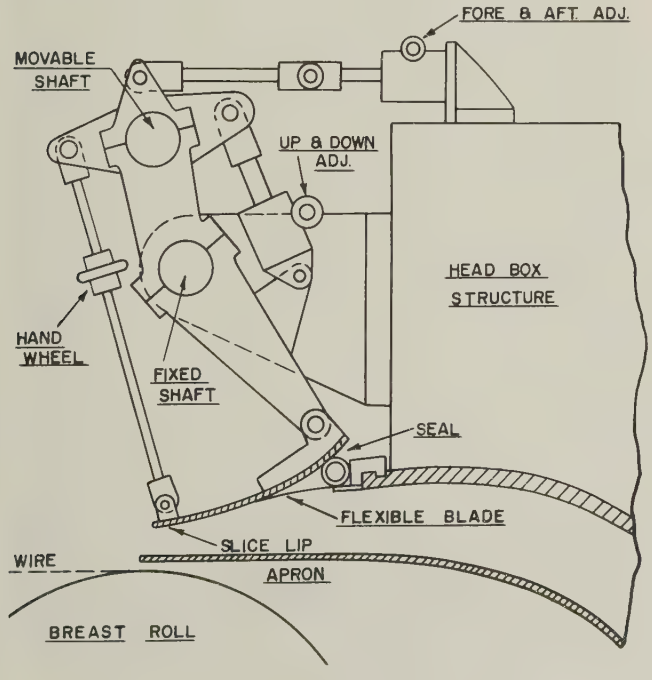

Fig. 3. Slice mechanism

Figure 3 shows the final arrangement of the slice. In addition to the points previously mentioned, provision is made to adjust the fore-and-aft position of the upper blade during machine operation in order to achieve some measure of control of formation by varying the direction and turbulence of the jet. The slice blade is not connected directly to the inlet. It is mounted on a cylindrical shoe which is pivoted at the ends of a number of slice arms. The slice arms are mounted on a shaft, which is attached to the headbox frame. The upper end of the slice arms carries another shaft to which are fixed the individual adjusting rods of the slice lip. Rotation about the fixed shaft causes the slice to be advanced or retarded as desired. Rotation of the upper shaft lowers or raises the slice lip. The area between the upper wall of the inlet and the slice lip is maintained in a smooth contour by means of a flexible doctor blade which is firmly clamped to the headbox across the inlet and bears with considerable pressure against the slice lip. The blade is so arranged to maintain a smooth contour through the entire range of slice adjustment. Between the back portion of the slice blade and the upper inlet wall a highly flexible seal of special design is installed to prevent leakage of stock past the doctor blade and out of the headbox. This arrangement permits the desired operating adjustments to be made easily while the machine is in operation.

STOCK SUPPLY

One factor that requires careful attention with the full pressure inlet of this type is the uniform delivery of paper stock to the inlet. Since the inlet runs full, the volume of stock contained is constant and variations in delivery to the inlet produce equivalent variations in the discharge at the slice. There is no element inherent in the inlet that will act to dampen pulsation or variation in the flow, such as the air dome in conventional types. It is necessary to eliminate or minimize sources of irregularity and pulsation of the flow at their source or to provide means external to the inlet to dampen these variations in order to operate successfully. In this connection, it should be noted that an air dome inlet is not necessarily free of pulsating discharge at the slice. A fan pump of special impeller design is used so as to reduce pressure pulsations in the delivery of the fan pump to the point where they do not produce detrimental effects at the slice. To further improve the uniformity of delivery, the fan pump is equipped with a variable speed drive designed to hold the speed uniform within $^{1}/_{4}$ of 1% of any desired speed regardless of variations in load or line frequency of the supply to the driving motor. In addition, the fan pump is supplied by a chest open to the atmosphere in which the level is carefully controlled. The pump is located well below the surface of the chest so that it will operate under a positive head and reduce fluctuation due to air binding or cavitation. The variable speed drive is especially valuable on a wide range machine, because the pump may be adjusted to deliver exactly the correct head and volume required for a given set of operating conditions. This eliminates the necessity of throttling the flow and dissipating large amounts of energy in the stock stream at low flow and speed conditions. Such throttling can result in the wide fluctuations in delivery due to turbulence at the throttling valve. In addition,

the headbox and associated piping must be supported in a manner that is free of vibration from associated equipment, as this vibration is likely to be transmitted to the slice in a manner similar to the hydraulically induced pulsations.

MECHANICAL DETAILS

Some mechanical details may be of interest. It was decided, in consideration of the wide corrosion conditions anticipated, to use type 316 extra-low carbon stainless steel, despite the extra material cost involved. Experience has shown that this material is superior to 304 stainless steel with respect to a pitting type of corrosion that may occur with paper stocks and reduce the quality of the surfaces substantially with the passing of time. The extra-low carbon material was specified to eliminate or reduce the necessity for heat treating following welding without loss of corrosion resistant properties. The approach piping, manifold branch pipes and diffusors were specified as a 2b finish for anticipated velocities of from 3 to 12 f.p.s. In the headbox proper where the velocities run from 1 to 4 f.p.s., no. 4 polish was specified on the skins.

Mechanically, the inlet itself is designed for a maximum deflection of $^1/_{16}$-in. in the area from the divergence to the 6-in. distributor roll. Forward of the 6-in. distributor roll the design standard was raised to $^1/_{32}$-in. maximum deflection, as variations in cross section in this area have much more effect upon the discharge at the slice. In addition, the nozzle surfaces forward of the 6-in. roll are planed to provide absolute uniformity of cross section. The inlet is arranged to be supported on sole plates in line with the sole plates of the fourdrinier, thus simplifying installation of the equipment.

OPERATION

The value of the theorizing and the experimental work described is, of course, proved by the operating results that were obtained in the completed unit, and the remainder of this discussion will be devoted to those results.

The inlet was placed in continuous operation in January, 1957, so that we have about one year of operating data to draw upon. There have been some very successful aspects in the operation of the unit, and there have also been difficulties, many of which have been eliminated. The machine has been operated principally in the range of 800 to 1100 f.p.m. making sheets varying from 30 to 60 lb. in both bond and printing papers. Production has included sheets up to 20% ash and in a number of finishes. In addition, the inlet alone has been run on water to jet speeds in excess of 2000 f.p.m., and under these conditions the jet appears remarkably smooth and free of excess turbulence. The mechanical design of the inlet is adequate at this pressure with respect to deflection and proper sealing.

BASIS WEIGHT PERFORMANCE

The production suffered initially from poor basis weight distribution and it was felt at one time that the entire design was a failure because of spearheading which appeared superficially to be related to the eight branch pipes. Further investigation, however, indicated that faulty machining of the individual slice

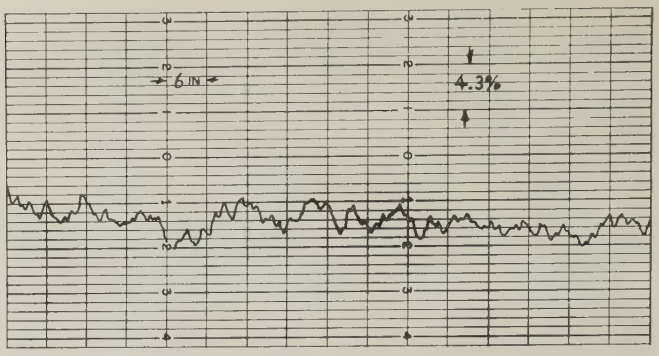

Fig. 4. Typical machine direction basis weight profile

adjusting screws made the local adjustment of the slice very difficult and resulted in the machine tender inadvertently putting permanent localized distortions into the slice lip. These distortions, impossible to eliminate by adjustment of the individual screws, caused streaks on the fourdrinier that were misinterpreted as related to the branch pipes. A stiff bar $^1/_4$-in. thick and with a machined knife edge was installed on the discharge edge of the slice. On the start-up after this installation the slice was levelled and samples taken of the initial operation. The machine-direction profile and across-the-machine profiles are reproduced. These are at a machine speed of 1090 f.p.m., manufacturing a 15-lb. bond paper. These profiles, incidentally, were made on moisture-free samples and therefore indicate the actual weight of paper rather than paper and moisture.

The machine-direction profile (Fig. 4) shows a maximum deviation of only ± 2.0% from the average sheet weight in a 200-ft. sample, with the average deviation substantially less. This type of profile is a good indication of the stability of an inlet, as it represents the fiber delivered at one point of the slice with respect to time. The figure of deviation obtained is an indication of the maximum sheet uniformity that one may expect to achieve with perfect slice adjustment. This uniformity is directly related to the scale of turbulence at the slice, as the fluctuations in delivery are the result of turbulence. Figure 5 is a recording of the fluctuations in static pressure at a point of the stock stream before the slice. The way in which these pressure fluctuations, due to turbulence, are related to the machine direction basis weight can be seen qualitatively by a comparison of the two graphs. It should be noted that the variations in basis weight are smaller in amplitude than the pressure fluctuations. The fourdrinier, especially at lower speeds, has some opportunity to even out variations in headbox discharge. As the time of drainage decreases, however, with increased speed, the leveling effect of the fourdrinier decreases, emphasizing the need for low turbulence at the slice.

Figure 6 shows a recent cross-machine profile. It is possible in typical operation to achieve an extreme basis weight distribution of less than ±3$^1/_2$% of average

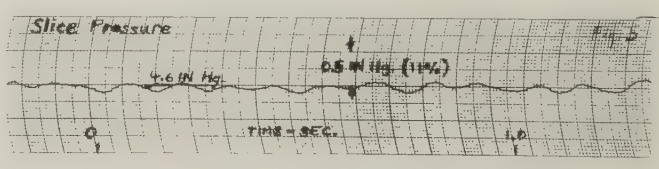

Fig. 5. Typical slice pressure recording

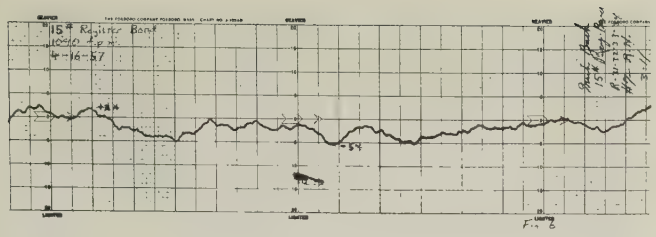

Fig. 6. Typical cross machine profile

sheet weight. The average variations are considerably less.

Figure 7 is a high-speed photograph of the jet issuing from the slice. It can be seen that the discharge from the slice is quite smooth and the stock on the wire is not appreciably disturbed until passing the first table roll. Visual observation of the fingers of stock issuing from the slice shows a side-ways wandering of less than 1-in. at a distance of 1 ft. from the slice. The photograph and these visual observations are further indications of the attainment of the low degree of turbulence necessary for satisfactory uniformity at higher speeds.

The operation of the inlet was confounded for some time by a phenomenon that is associated with uniformity. This was the occurrence of a violent pulsation in the flow of stock from the headbox, characterized particularly by its intermittent appearance. The nature of this pulsation and its cause have been explored in a previous paper by Reitzel (*5*). It is sufficient to say that it was conclusively demonstrated that these pulsations occurred in external equipment and were transmitted through the inlet. External sources of vibration have often plagued inlet operations. In practice, the operator is forced to struggle with them until they are reduced to manageable proportions by manipulating the many variables on the wet end of the machine. Although the fundamental source of difficulty is recognized as the screen arrangement, corrective action has not yet been taken here. The pulsation has been brought under control by machine adjustment. Occasionally, however, the pulsation occurs under conditions beyond the control of the operator, and production suffers. Elimination of pulsation at the source is indicated to insure complete operating reliability.

It is apparent from the excellent basis weight profiles produced that the performance of the single-ended distributor is satisfactory. Table III gives the flows measured in the eight branch pipes at various total stock flows. It was mentioned previously that flow meters and control valves were installed in each of the 8-in. branch pipes for the purpose of equalizing flow. It was found, however, that the flows did not differ substantially from each other and are constant in time,

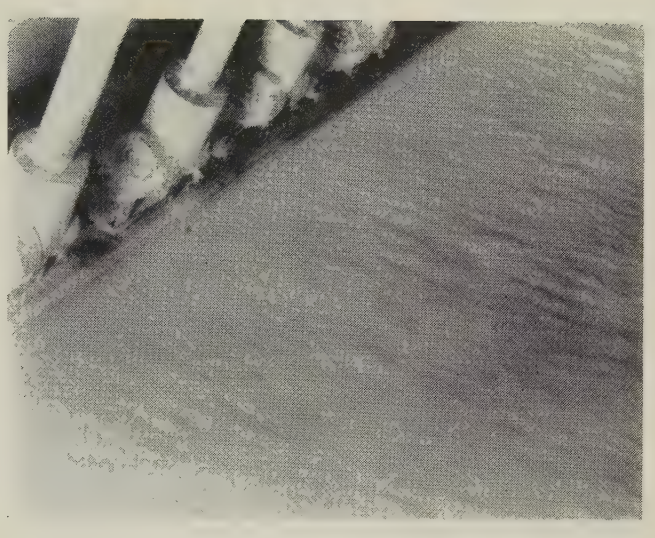

Fig. 7. High-speed photograph-headbox discharge

with controllers inoperative and the control valves set wide open. The operating adjustment of the inlet was much more complicated with the meters in operation, and it was decided, since satisfactory distribution is achieved at the slice, to eliminate them from the circuit. The distributor flows and basis weight profiles previously given were recorded with the control valves inoperative.

A full-sized individual diffusor was constructed in our laboratory and the velocity profile at the discharge from the diffusor was taken. Figure 8 gives this profile. The drop in velocity at the wall of the diffusor is only 8% of the average velocity for a flow of 900 g.p.m. It may be assumed that a series of these diffusors with essentially equal flow to each will deliver to the headbox a uniform flow across the width of the machine with the exception of a velocity reduced 8% for a few inches at the intersection of two adjacent distributors. This represents a very minor discontinuity and, as evidenced by the basis weight profiles, is easily wiped out by the headbox.

The development of crossflow in the unit is very small after the distributor. An experiment was performed in which a dye stream was injected at the intersection of two adjacent diffusors and it was found that this stream spread to a width of only 8-in. in the finished sheet. This is substantially less cross diffusion than is commonly experienced, and is a further indication of the accurate distribution achieved in the single-ended distributor design.

SHEET FORMATION

The complex problem of formation has been solved with a fair degree of satisfaction. It should be remem-

Table III. Distributor Branch Pipe Flows

Total flow, g.p.m.	*Av. flow, g.p.m.*		*Branch pipe* 1	2	3	4	5	6	7	8
4690	586	Flow	535	565	620	610	560	610	545	645
		% Dev.	−9	−4	+6	+4	−4	+4	−7	+10
5650	706	Flow	650	675	735	740	680	740	660	770
		% Dev.	−8	−4	+4	+5	−4	+5	−7	+9
6410	801	Flow	740	770	820	840	770	840	760	870
		% Dev.	−8	−4	+2	+5	−4	+5	−5	+9
7630	953	Flow	870	910	990	990	910	1000	920	1040
		% Dev.	−9	−5	+4	+4	−5	+5	−3	+9
8525	1065	Flow	960	1020	1120	1100	1030	1120	1025	1150
		% Dev.	−10	−4	+5	+3	−3	+5	−4	+8

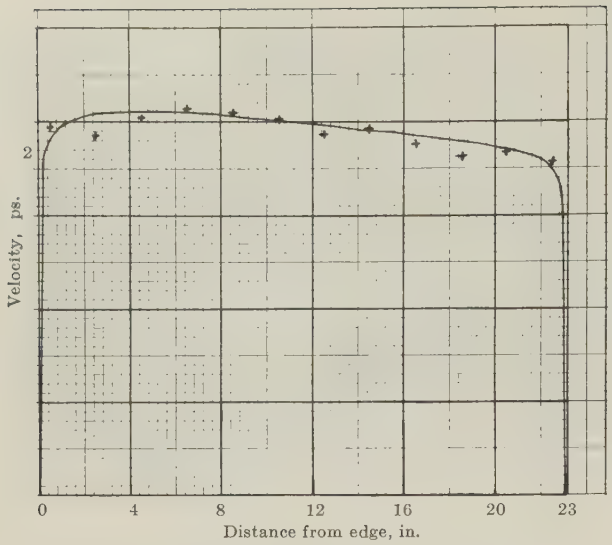

Fig. 8. Individual diffusor velocity distribution

bered that the formation achieved depends on many factors other than the slice or the headbox. The composition of the paper stock, the operation of stock preparation equipment, and the drainage conditions on the fourdrinier are of equal importance, and to achieve a given formation requires the proper manipulation of all these factors. The entire operation of forming a sheet of paper is such a complex matter that, when entering into a new realm of speed or product, a great deal of experience must be gained by the operators in the manipulation of a specific system before successful results are obtained. It has taken sometime to achieve the desired results on this particular machine, but at present the mill is able to produce a properly formed sheet of most production grades up to 1100 f.p.m. The ability to adjust the fore and aft position of the upper slice lip while running has, according to the operators, played a large part. Movement of the upper slice lip affects the direction of the jet. With the upper slice lip substantially to the rear of the apron (2-in.), the jet is essentially horizontal, being guided by the apron. As the slice lip is moved forward, the jet is deflected downward. Observation indicates that the deflection of the jet is gradual, stable and uniform across the width of the machine. It occurs while the apron is still substantially protruding. No theoretical explanation of this action is offered, but it is probably related to the hydraulic properties of the slice passage and approach. It is felt, however, that if the jet is directed downward into the wire the state of turbulence of the stock on the wire increases and of course the amount of pressure formation increases. The common newsprint practice of sloping the apron to the wire at a small angle is an application of this observation, and is considered a valuable function by newsprint operators. It is certain, however, that the operators of the machine consider this adjustment a valuable function and of substantial assistance to them in achieving desirable formation.

CLEANLINESS EXPERIENCE

The major operating problem faced to date has been the cleanliness of the interior surfaces of the inlet. This problem is still with us, although recent work has substantially improved the condition. All grades produced have shown to a greater or lesser degree an intolerably large number of holes and stock lumps, the light grades and those containing larger proportions of long fiber being of the lowest quality.

Examination of the interior surfaces of the inlet and piping showed heavy stock build-up due to poor installation at gasketed joints and at welding defects. These defects were corrected as far as possible and an improvement in the stock build-up conditions of these areas was noted. The dirtiest area of the box, however, lies on the upper surface between the 6-in. roll and the slice. Under certain operating conditions it was possible to build up a dense deposit of strings as long as 2-in. in a matter of 8 hr. after hosing the surface free of strings. It was most interesting to note that the upper surface in this area collects strings very badly, while the lower surface, which is of approximately the same surface finish and subjected to the same velocities, shows negligible build-up. This is felt to be an indication of the effect of air and foam on the dirtying of headbox walls. This area is of course that in which air tends to collect, as it is the highest point of the inlet.

It was found that the stock deposits had two characteristic components. Over a relatively long period of time, that is, several months, the surfaces of the inlet develop a hard deposit apparently containing glue, filler, and short fibers. This deposit is remarkably difficult to remove by a simple hosing operation and requires either wetting and mechanical action or a caustic boil-out for substantial cleaning. This deposit is not in itself particularly harmful, but it has the effect of producing a very rough surface finish. The secondary build-up is in the form of strings which easily attach themselves to the rough surface presented by the primary deposits. These strings build up from the long fibers in the stock and grow in length until the force of the stock flow is sufficient to break them loose, carrying them out on the wire of the paper machine. These strings can be knocked down by hosing. However, the relatively rough surface, which is not corrected by a simple hosing operation, remains. Thus build-up of strings is exceedingly rapid and the quality of the sheet falls quickly after a simple clean-up. It was found, however, that substantially longer periods of satisfactory operation will result if the primary deposit can be reduced by more thorough clean-up procedures.

The main difficulty with respect to clean-up is the inaccessibility of the interior surfaces of the inlet. Although efforts were made in the original design to make the surfaces accessible by means of a removable section of the inlet proper and by access through the slice, it was found that in practice the clean-up operations were unreasonably time-consuming. Current efforts are being devoted to the development of rapid means of opening the inlet for clean-up and of improved access from the slice. At the same time showers and similar equipment are being developed that permit a rapid wash-up of the inlet during normal shutdown. The objective is to achieve a cleaning procedure that can be performed at expected machine shutdowns, such as wire changes or changes of grade, that will maintain the inlet in satisfactory condition. When this objective is achieved the inlet will be satisfactory from the point of view of cleanliness. The mill is doing its part by exploring chemical cleaning techniques appropriate to the

installation and the types of stock used, and in the trying out of improved cleaning procedures.

AIR HANDLING

Two provisions were installed to prevent the collection of air in the inlet and the discharge of excessive amounts of air on the wire of the machine. A longitudinal slot through which air-rich stock might be bled was provided on the manifold in the distributor. Another slot the width of the machine was provided at the high point of the inlet to prevent the collection of residual air in the stock at this point. Studies were made of the air content of the stock in various portions of the inlet. The apparatus described by Boadway (*6*) was used for this work. Some interesting conclusions can be drawn from these studies. Most apparent is the failure of the bleed-off in the header to eliminate any significant amount of air from the stock despite the operation of the bleed-off at rates to 500 g.p.m. or about 10% of the stock flow to the inlet. A tendency of the air to stratify in the main approach pipe could not be detected experimentally. However, it was observed that stock build-up was heavier on the top surfaces of the manifold and approach piping, indicating the presence of air or foam. At the high static pressures, 25.4 in. of Hg, existing in the manifold, the greater part of the free air in the stock coming from the screens is forced into solution and cannot therefore be removed by this arrangement. Free air in the screen pit at atmospheric pressure is typically 1.36% by volume. The stock passes to the header in a matter of 60 sec. transit time to a pressure of 25.4 in. Hg, where the free air is reduced to 0.96%. The stock then passes to the slice where at 1000 f.p.m. approximately 4 ft. of water head exists. In this area it should be noted that the concentration of free air has increased slightly to 1.07%. It was found that bleed-off in the distributor has no measurable influence on the amount of air at the slice or on any other operating factors of the inlet, such as cleanliness, and we are currently operating with a negligible flow to prevent the collection of gross amounts of air in the manifold.

The upper slot bleed-off has been operated under a number of varying conditions. It was felt at one time to be a source of the stock lumps experienced and was accordingly closed by a suitable plug. This, however, had no effect on the cleanliness and gave rise to the occasional discharge at the slice of large amounts of air. In an attempt to improve the cleanliness of the area between the 6-in. roll and the slice by improving the removal of suspected foam, the bleed-off has been operated up to 850 g.p.m. Operation at this high flow produced a very large number of foam spots as well as substantially increased discharge of stock lumps. It is felt that this condition might be due to high turbulence in the flow through the slot, resulting in the release of small air bubbles, causing the foam spots, and in an increased rate of washing away of strings, causing the stock lumps. Currently this bleed-off is operated with the plug installed, and a reduction in stock lumps has been noted. This new operating condition is concurrent, however, with the introduction of substantial improvements in cleaning procedures, and it is hard to assign the improvement to changed bleed-off conditions. However, difficulties with the discharge of air should be anticipated. Observation on the model indicates that substantially all free air in the upper part of the flow will rise into the slot with little or no bleed-off.

MECHANICAL DIFFICULTIES

Several mechanical difficulties appeared which have been or are in the course of being corrected at this time. For example one particularly troublesome factor during initial operation was a set of faulty slice adjusting screws which made actual adjustment of the slice exceedingly difficult. In the course of normal operations, permanent deformations were introduced into the slice which gave rise to the machine direction streaking previously described. These screws and the slice lip are currently being replaced.

At one time in the course of operations it was felt that the slice seal previously described gave rise to the pulsations observed due to vibration of the flexible sealing blade. It was also thought that leakage through the seal produced dewatering of the stock and thus caused a build-up of strings where the doctor blade contacted the slice lip. The sealing arrangement was therefore changed to eliminate the flexible blade and leakage past the contact of blade and slice. It was found, however, that these changes produced no improvement in problems of cleanliness or pulsation. Several operating advantages were lost in the change, including the range of adjustability of the slice lip and the ability to lift the lip to a large opening for cleaning the interior of the box. Since no gain resulted and the operating advantages were lost, it has been decided to return to the original sealing arrangement in a mechanically improved version, and these changes are currently being made.

The 6-in. distributor roll described has proved satisfactory from the point of view of cleanliness and mechanical strength. However, the bar rolls in the two lower positions have presented considerable mechanical difficulty. The bar roll is eminently satisfactory from the cleanliness point of view and in the position used there was no evidence of sheet marking. However, the bar roll installed in the 10-in. position has already failed mechanically by going out of line and rubbing the wall of the box. In addition, the bar roll proved difficult to make, requiring a great many fabricated parts, and was particularly difficult to straighten after fabrication. Although the roll is satisfactory in operation from the paper stock point of view and can be mechanically strong, it is not felt to be as economical as a perforated roll. Another thick-walled roll similar to the 6-in. roll was installed, and this has proved entirely satisfactory. Although straightening veins were incorporated in the two lower rolls originally supplied, they have not proved necessary since the crossflows in the box are quite small.

Although it was felt that the initial arrangements for opening the inlet for cleaning would be sufficient, the cleanliness problem that developed indicated the need for reducing to a minimum the time required to gain access to the interior of the inlet for cleaning purposes. The original arrangement involved an excessive amount of down time and labor to perform a proper cleaning job. Therefore minor modifications are being made to reduce the labor of bolting and unbolting and opening and closing the removable section of the inlet. In addition, the modifications previously described to the slice

will make it possible to effectively wash the interior of the inlet from the 6-in. roll to the slice by introducing cleaning equipment through the slice.

The fan pump drive previously described, a unit employing a magnetic clutch drive by a constant speed induction motor, in which the slip of the clutch is varied to adjust the fan pump speed, presented some problems initially. Due to improper installation, the unit was severely overheated and several bearing failures occurred which shut down the machine. An adequately ventilated installation has since been made and there have been no difficulties with bearing failures in the past 4 months. It was also found that the operating control on this unit was too sensitive for easy operation by the machine tender. A simple modification to the control system enabled us to give the control the correct operating characteristics and greatly simplified the machine tender's job in correctly adjusting the speed of the fan pump.

OPERATION OF SIMILAR UNIT ON TISSUE

It is of interest to make a few comments about a similar pressure inlet installed in southern tissue mill. The design and construction of the tissue inlet is very similar to the inlet discussed here. There are, however, a few differences that are worth mentioning. In this installation a deculator is used and the manner of flow control to the inlet is somewhat different. The deculator feeds the fan pump and the deculator level and pressure are controlled. Stock flow to the inlet is controlled by a by-pass line with a control valve which recirculates the surplus stock. This valve is pressure controlled by the pressure drop through the inlet. The fan pump is operated at constant speed. The performance is satisfactory with respect to stability of delivery. However, the requirements are less, as this is a narrow range machine and little throttling of the fan pump is needed. Also, the nature of tissue formation does not require such close attention to headbox delivery conditions. An installation of this type would not be considered for a conventional fourdrinier operation for these reasons. Meters were installed on this unit also. They have since been removed for reasons already discussed. The manifold arrangement of this unit is of a simple variety in which an upwardly sloped tapered manifold extends across the width of the machine immediately below the branch pipes. The branch pipes leave the top of this manifold and go vertically upward into the inlet. This arrangement was adopted because, with the use of a deculator, it was assumed that there would be no difficulty with the handling of air in the system. For the same reason no slot was provided in the high point of the inlet. This installation is presently operating at speeds to 2600 f.p.m.

One of the most interesting facts about the tissue installation is that there has never been any cleanliness problem in this mill. The reasons for it, however, seem apparent. In the first place, the tissue furnish used has received only a slight refining. Further, there is a minimum use of additives and no loading materials. This stock is inherently a great deal cleaner than the stocks used typically in fine paper manufacturing. It is also felt that the deculator, by the elimination of air from the system, plays a large part in increased inlet cleanliness.

FUTURE DESIGN

The experience gained on this first installation would be of little value if it were not employed to improve future designs. The excellent performance of the unit with respect to basis weight distribution, both across and in the machine direction, and to formation over a wide range of speeds and weights, indicates that the basic design is a sound one. It will be retained with little modification. However, difficulties experienced suggest some changes and some areas of design which need further consideration. Great care must be exercised in the elimination of pulse sources, both hydraulic and mechanical, which may affect the operation of the inlet. Much experience was gained, in manufacturing and operationally, on several types of distributor rolls. Future designs will employ a thick-shelled roll with relatively small perforations, of the type which is now operating successfully in the inlet. As the air-separating operation in the manifold has proved ineffective, future manifolds will be of the simple type described for the tissue inlet. The elimination of the header bleed-off will result in reduced cost and in improved cleanliness. The upper slot has proved effective in preventing the discharge of gross amounts of air from the slice, even with small bypass flows. On the other hand, difficulty was experienced with air discharge when the slot was temporarily plugged. This slot will therefore be retained in the future.

The biggest effort in the new design will be devoted to improving the cleanliness of the unit. Observation of the conditions of stock build-up in the diffusors, indicates that, even at the steep angle of 7° at which they operate, the upper surface is dirtier than the lower. The vertical pipes feeding the diffusors are, moreover, relatively clean. It appears that very small deviations from the vertical promote stock build-up. The diffusors will, therefore, be oriented vertically in the new design. Other changes that the new design incorporates will result in increased accessibility to the piping and diffusors and the interior of the inlet. Figure 9 shows a cross section of the most recent arrangement.

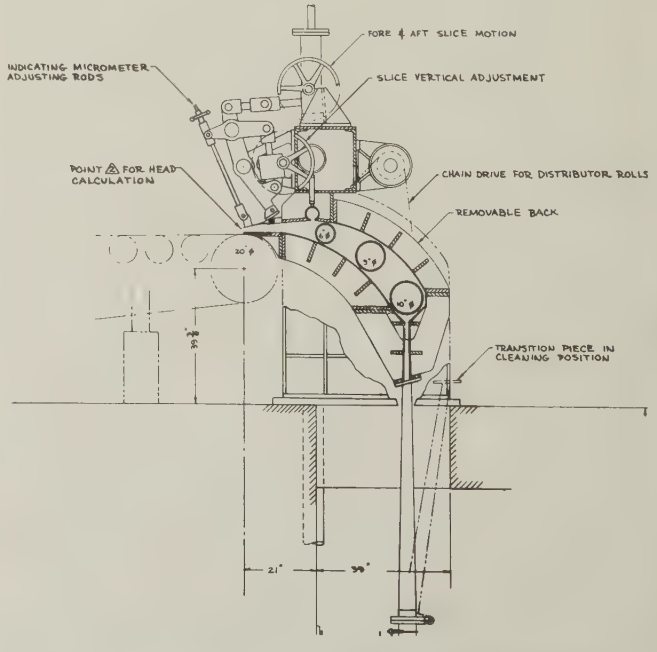

Fig. 9. Improved design proposed for future installations

Also, the closest attention will be paid in fabrication to improved workmanship, especially improved surface finishes and assembly in all parts of the inlet.

CONCLUSIONS

Every effort has been made to evaluate the performance of this inlet in measurable numerical terms. Regrettably, the state of our knowledge of inlets is such that many observations must, because of their complexity, be qualitative in nature. By the same token, many statements are as much expressions of opinion as of scientifically proved fact. These opinions are qualified as such in the text. The principal reason for the inclusion of material which does not necessarily meet the standards of a high degree of scientific evidence is the feeling that, in such a complex field as that of headbox operation, even limited experience can be of valuable assistance to those faced by similar problems.

On the basis of the information obtained, however, it is felt that the design has proved a successful solution to the initial problem proposed. In summary, basis weight distribution and formation have been proved satisfactory for a substantial portion of the operating range. There is no indication in the operations to date, that major difficulties in the inlet should be anticipated in extending the range of operations to the limits planned. The major current problem is cleanliness, but substantial improvements have been made in this respect in recent months, and it is fully expected that this problem will be reduced to practical proportions in the near future.

A moral can be drawn from this history by those who are faced with the problem of operating untried equipment in a paper mill. When performance is demanded that cannot be met with existing equipment, it is necessary to design new equipment which represents some degree of departure from current practice. Sound experimental and engineering work can produce a design that is essentially good. However, particularly under paper mill conditions, unforeseen problems will arise to interfere with satisfactory operation. This has been the most obvious characteristic of our work over the past year. The operation of this new stock inlet, although highly satisfactory with respect to some papermaking functions, has been confounded by numerous problems which are not related to the basic soundness of the principles employed. Most of the difficulties previously described are related to the external equipment, engineering and construction errors, and lack of experience of the operating personnel with respect to the specific equipment. Many difficulties have been solved and the problems that remain will be solved by a continued effort to accurately isolate difficulties and correct them. Generally, an easygoing and calm approach should be taken to all problems that occur, and hasty action which is not related to the problem in question should be avoided. The difficulties of working on a piece of production machinery in a paper mill are obvious, but it is strongly felt that if the engineer who works in the mill and the operating personnel who are required to maintain production will endeavor to appreciate each other's problems, most mill problems can be solved with a minimum of cost and lost production, as the many problems discussed here were.

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This discussion would not be complete without giving credit to the many individuals and companies whose efforts have made possible the design, construction and operation of the two inlets discussed. In particular, the P. H. Glatfelter Co. of Spring Grove, Pa., and the Hudson Pulp and Paper Co. of Palatka, Fla., deserve great credit for their courage in backing the development of these units. Appreciation is expressed particularly to the personnel of the P. H. Glatfelter Co. in the management, manufacturing, and technical departments, whose patience and unfailing assistance, even in the face of great discouragement has made possible the achievement of present operating conditions. Finally, credit is due to all members of the Rice Barton Research Department and their consultant, Gleb Goumeniouk for the group effort required in the conception, design and evaluation necessary in the successful development of a piece of equipment as complex as a stock inlet.

The Marathon Score Test

J. H. TEEPLE and R. G. NOLL

The principle of evaluating score quality by using the ratio of the strength of scored board to the strength of the same board unscored has proved useful. The strength test used is a bending test in which the maximum force needed to break scored and unscored specimens is measured. Results correlate quite well with subjective evaluations. A mill trial of two types of makeready established its value. It is now used in all of Marathon's carton plants.

THE traditional method of evaluating a score is to bend it by hand and observe the results. Judgment of the score quality is based on both vision and feeling and is colored by the observer's past experience and by the decisions he must make on the basis of his evaluation. As a result, two experienced observers will frequently disagree in their judgment of a score.

This situation has been recognized by the makers and users of folding boxboard and a more objective test method, which would give a numerical result, has been sought.

No single instrument would be expected to measure all the properties that a hand tester feels and observes but tests have been developed to measure single fundamental score properties. The choice of a fundamental property, however, has not been unanimous.

For example Paronen (*1*) measured several physical properties of scored board, e.g., bursting strength, tensile strength, and a modified Taber stiffness and expressed them as per cent of the same properties measured on the unscored board, to illustrate the effect

J. H. TEEPLE, Physics Group Leader and R. G. NOLL, Physicist, Marathon, a Division of American Can Co., Menasha, Wis.

of depth of creasing on score quality. In his final evaluation, however, he reverted to visual observation of the score.

The Concora folder gluer described by Long (*2*) folds two scores mechanically and passes them between

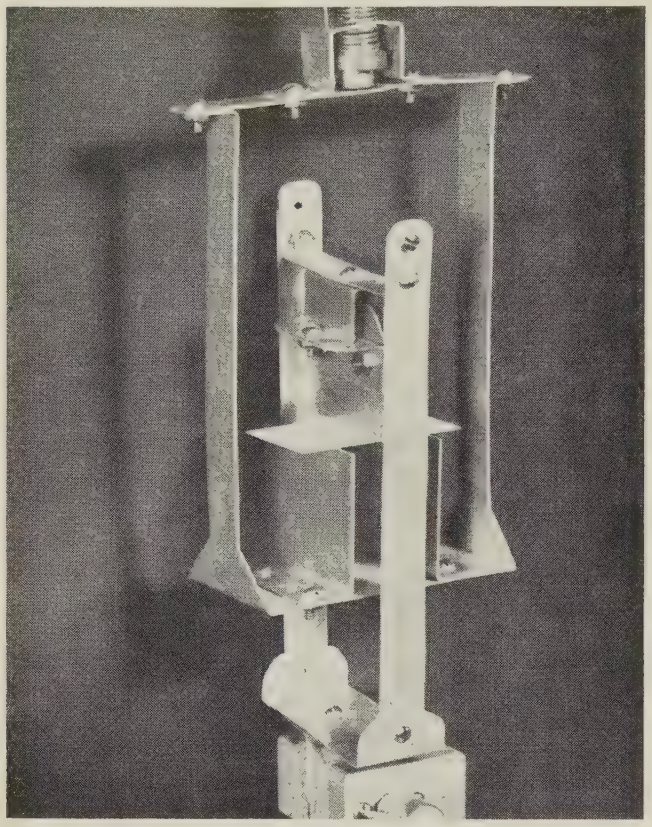

Fig. 1. The original bending jig mounted in a tensile machine

press rolls in a manner described as similar to the actual folding in commercial operations. It can also be used to make a glue joint.

Hine (*3*) suggested two methods, beside visual grading, for evaluating scores made by the PATRA carton board creaser. One was the measurement of the residual depth of finished scores. The other was measurement of the folding force per unit length of score for folding angles up to 180°. His paper showed curves of folding force against angle of fold. The rate of folding was comparable with commercial speeds. The method of folding was not described.

Kernan and Lewis (*4*) described an instrument for measuring the force necessary to open a knockdown carton or to fold a score.

At Marathon the choice of the measurement to be used in evaluating scores was based on the following considerations: The purpose of the score is to weaken the board so that it will fold easily without developing disruptive stresses along a chosen line. The effectiveness of the score is determined, not so much by the magnitude of the force required to break it as by the relative strength of the scored and the unscored board as shown by the ratio of the forces required to break each of them.

A good score in the cross direction will require a greater force to break than a good score in the machine direction simply because fibers are being broken instead of pulled apart. The ratio of scored to unscored board forces will be the same in either machine or cross direction, given two scores of equal quality.

Our original score testing device is shown in Fig. 1. The specimen is mounted between the upper and lower halves of a bending jig. The upper half of the jig is supported by a spring balance which indicates the force on the specimen. The lower half is held by the lower jaw of a tensile machine to give it uniform downward motion. During the test the force rises to a maximum and then falls off as the scored or the unscored specimen breaks. The maximum force is observed and recorded.

The result is reported as the "score ratio." It is the ratio of the maximum force required to break the scored specimen to the maximum force required to break the unscored specimen multiplied by 100 so as to be expressed in per cent. A score so poor that the full strength of the unscored board is retained would give a score ratio of 100%. One so severe that it cut the board almost in two might give one of 20%. The desired score ratio is obviously somewhere between these extremes.

The score tester results were compared with the ratings given by hand tests in one of our carton plants. Scores were selected from a group which had been tested on the instrument to form a set of about 30 scores whose score ratios varied from 34 to 84%. These were submitted to a panel of five men for subjective evaluation. The panel was composed of men on whose judgment of scores the plant depended. They classified the scores as "very good," "good," "fair," and "poor." The panel members had predicted that they would disagree on some of the scores, and the results bore them out.

They were almost unanimous in rating scores whose ratios were 50% or lower as "good" or "very good."

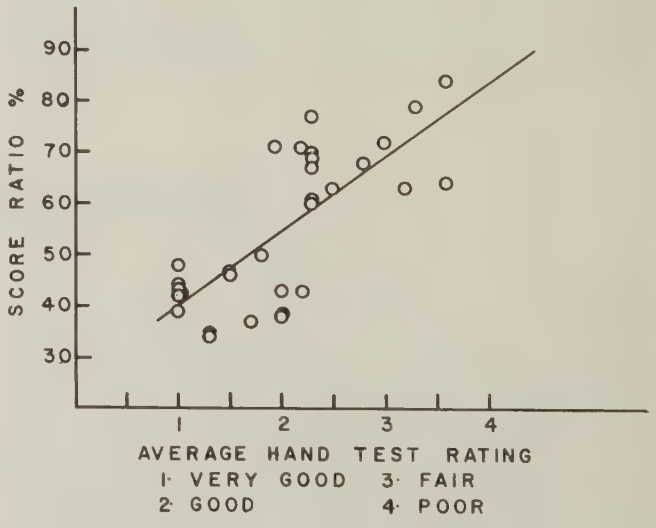

Fig. 2. The relation between score ratios and the numbers assigned to average hand test ratings

Scores with ratios above 50% seemed to be more difficult to evaluate. Of the 15 scores that fell in this range six were each placed in three different categories by the panel members. For example, a score which

the instrument rated as 79% was judged "poor" by two members, "fair" by two others, and "good" by the fifth.

In order to handle their results numerically, arbitary values were assigned to the different ratings. "Very good" was 1, "good" was 2, "fair" was 3, and "poor" was 4. Using these numbers, an average numerical rating of each score by the whole panel was calculated. These values are plotted as abscissas in Fig. 2. Score ratios determined on the instrument are plotted as ordinates.

The correlation is significant at better than the 0.001 level. There is, however, a very considerable scatter. This was ascribed, partly, to the differences of opinion within the panel and, partly, to the fact that the instrument measures only one property while an observer sees many different qualities. The use of integers to describe score ratings also contributed.

The separation between scores with ratios below 50% and those with ratios above 50% is very evident. Only one of the scores of 50% ratio or less was rated less than "good." Only one of the scores of 60% ratio or above was rated as high as "good."

One early application of the score tester was to illustrate the superiority of one type of cutting and creasing makeready over another type. Makeready A was believed by observers to produce good scores longer than makeready B, but their judgment was not convincing enough to warrant a change-over. The results of use of the score tester to compare these makereadys are shown in Fig. 3 (*5*). For each makeready the score ratios plotted here are from the same machine and cross direction scores made in a single die position during a normal production run.

The scores made with makeready A showed no tendency to deteriorate at 300,000 impressions. The score ratios started and remained not greater than 50%. The cross direction scores made with makeready B showed continuously increasing ratios, until, at 230,000 impressions, the cutting and creasing superintendent decided by hand testing, that the makeready needed changing. The score ratios of the machine direction makeready B scores showed more variation, but all of them, after 60,000 impressions, remained above 50%.

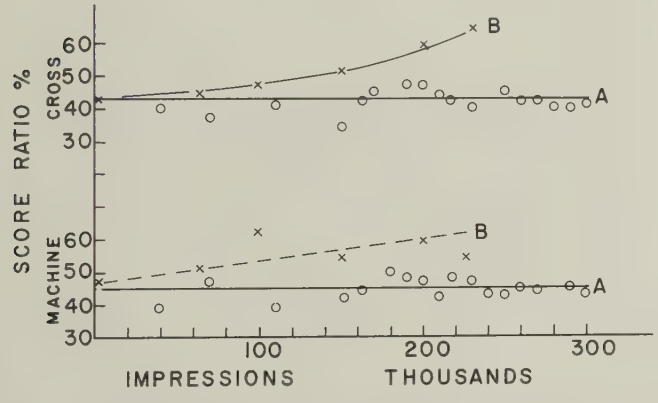

Fig. 3. The score ratios of two cutting and creasing makereadies as a function of number of impressions

The scatter can be ascribed, at least in part, to board variables.

Two years subsequent experience with makeready A has demonstrated its superiority to makeready B. These results strengthened the conclusion that the test measures a basic score property.

The original score tester was slow in operation because of the softness of the spring balance, and the return time of the lower jaw of the tensile tester. Also, it was not readily portable. A new tester was built to overcome these defects. It is shown in Fig. 4.

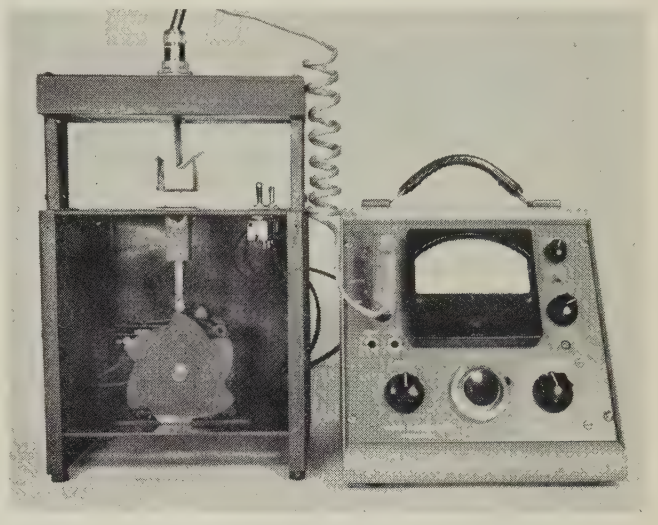

Fig. 4. The finished instrument with a broken specimen in place

The test is conducted in a bending jig as before. A motor driven cam replaces the tensile machine. It moves the lower half of the jig carrying the specimen, upward at 4 inches per minute. The upper half of the jig (the breaker) is connected to a spring steel strip mounted as a beam. Strain gages are bonded to the beam. The push of the specimen against the breaker bends the beam and actuates the strain gages. The force can be read on the meter of the bridge-amplifier-meter shown on the right. The Marathon score testers are calibrated in ounces to insure readings that are large enough for accuracy and small enough to keep the meter on scale. Those are the only reasons for calibration since calculation of the ratio eliminates the units used in measuring the forces.

Test specimens are 1 by 2 in. In scored specimens the score runs parallel to the 1 in. edge and is in the center so that it will strike at or near the breaker. The exact position is not important. In the interest of speed the scored and unscored specimens are cut as a single piece $3^1/_2$ by 1 in. with the score 1 in. from one edge. This reduces specimen cutting and specimen changing time and insures that the tests of scored and unscored specimens are made from the same grain direction of the same board. Five scored and five unscored precut specimens can be tested in 2 min.

This test was not aimed at high precision, but it has proved very useful. It is accepted by the men who evaluate scores by observation. The instruments are used in all Marathon's carton plants.

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The Effect of Crushing as a Wood Pretreatment

W. F. COWAN

Compression of wood blocks in an axial direction and subsequent pulping with a kraft cooking liquor produces a definitely weaker pulp. Evidence is presented to show that this loss in strength is due to a decrease in inherent fiber strength. Although the detailed mechanism by which the fibers are weakened remains obscure, a possible explanation is advanced. The physical strength data collected imply certain fundamental aspects of paper strength tests. These are discussed in some detail.

Rapid cooking is fast becoming a major objective of the pulp and paper industry. Under conditions where over-all cooking times are significantly reduced, the time required for the liquor to penetrate into the wood assumes singular importance. One method of reducing penetration time is to open up the wood structure through some form of mechanical treatment such as shredding or crushing. Several workers (*1–5*) have indicated that such treatment results in a decrease in the strength properties of the pulp produced. However, no systematic study of this phenomenon has been reported in the literature to date.

The work described in this paper attempts (1) to demonstrate the precise effect of crushing of wood blocks on the strength of the pulp produced therefrom, and (2) to elucidate reasons for such effects. The study is, however, restricted to sprucewood cooked by the kraft process. Although chemical pulping of mechanically damaged wood apparently yields inferior pulp, the manner and extent to which the pulp is degraded may be dependent not only on the mode of cooking, but also on the type of wood used. Thus, the results and conclusions presented in this paper are strictly applicable only to sprucewood cooked by the kraft process.

The nature of the results obtained in the study of the crushing phenomenon imply certain interesting characteristics of paper strength tests. These are discussed in a concluding section of this paper.

As a final introductory note certain limitations of this study should be stressed. The experimental program is of an introductory nature. Although certain observations are sufficiently striking to allow solid conclusions, others because of lack of more extensive data are merely suggestive. With this reservation in mind it is felt that the results of this study should prove useful in orienting some of the thinking in this area.

EXPERIMENTAL PROCEDURES

Wood blocks 2 by 2 by $^1/_2$ in. were obtained from a spruce log with the $^1/_2$ in. dimension being parallel to the fiber axis. The blocks were soaked in water for several days to ensure a high moisture content. (It was found that crushing *dry* blocks produced an undesirable higher density block, while water saturated wood was reduced to spongey, easily penetrated material.) Half of the soaked blocks were reserved for preparation of normal uncrushed chips. The remaining ones were subjected to a heavy compression load in a 100-ton hydraulic press. A load of 25 tons applied for 10 sec. was sufficient to produce severe compression failure and considerable structural disruption. The manner of crushing is demonstrated in Fig. 1.

The crushed blocks were reduced to chip size by manually breaking them apart. The untreated water soaked blocks were hand chipped using hammer and chisel.

All cooks were conducted using the following digester charge:

300 grams wood chips (oven-dry basis)
160 grams NaOH
105 grams Na_2S
5000 grams H_2O

The high alkali concentration and sulphidity indicated by the above figures were employed in order that these values would remain relatively constant throughout the cook. The digester used is shown schematically in Fig. 2. The heating element contains a relay system designed to achieve and maintain any desired temperature. All cooks were given a 1-hr. heating up period to 170°C, after which the time at this temperature was altered to produce pulps of varying lignin content. At the end of the cook the digester temperature and pressure were rapidly reduced by circulating cold water through the heat exchanger. In order to defibrize the cooked chips, they were subjected to a single pass through a Sprout-Waldron laboratory refiner with a plate setting of 0.020 in. The pulp was then thoroughly washed, dewatered on a Buchner funnel, and stored in polyethylene bags. Four pulps of varying lignin content (6.5 to 13%) were prepared from uncrushed

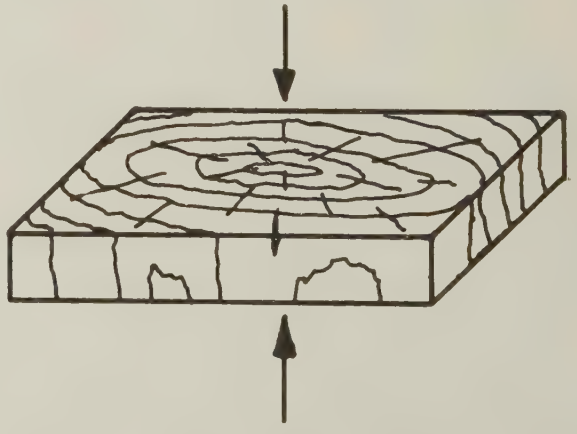
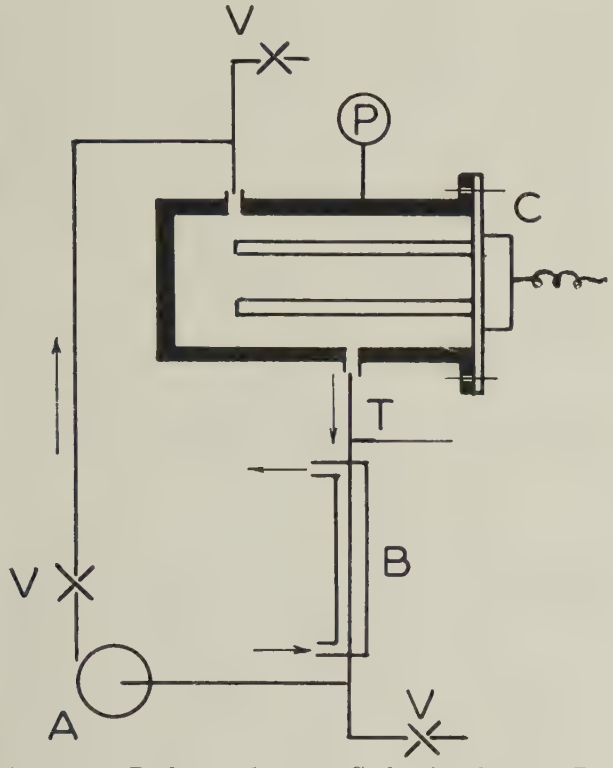


Fig. 1. Orientation of wood block during crushing

W. F. Cowan, Doctoral Thesis Student, The Institute of Paper Chemistry, Appleton, Wis.

wood chips and will be referred to henceforth as "uncrushed pulp." Three pulps (6.5 to 18% lignin content) were prepared from crushed wood chips and will be referred to as "crushed pulp."

In order to determine whether the crushed pulp differed chemically from the uncrushed, the following



A—pump. B—heat exchanger. C—heating element. P—pressure gage. T—thermometer. V—valves.

Fig. 2. Schematic drawing of digester

tests were made: Klason lignin values for each pulp were determined. In addition, a mild chlorite treatment followed by an alkali extraction was used to quantitatively estimate the alpha-cellulose content of each pulp. The alpha-cellulose derived from one crushed and one uncrushed pulp sample of equal (6.5%) lignin content were tested by the cupriethylenediamine viscosity technique for average degree of polymerization (D.P.).

The physical properties were obtained for pulp beaten 20 min. in a Jokro mill. This procedure was adopted on the basis of data obtained from preliminary beater development curves of both crushed and uncrushed pulps. The physical tests conducted on standard handsheets from all pulp samples were:

1. Basis weight and caliper
2. Mullen burst strength
3. Elmendorf tear strength
4. Schopper tensile strength
5. M.I.T. fold endurance
6. I.P.C. zero span tensile strength
7. V.V.P. bonding strength

PRESENTATION AND DISCUSSION OF RESULTS

Effect of Crushing

To reach a given level of lignin removal required significantly less cooking time for the crushed than for the uncrushed wood chips (see Fig. 3). Since the chips were not presaturated with cooking liquor, the decreased cooking time could be entirely due to a more rapid penetration of the liquor into the more open structure of the crushed wood. However, it is also possible that the crushing increases the available reaction surface and thus actually causes an increase in the rate of the pulping reaction.

Table I. Fiber Classification—Unbeaten Pulp

	Uncrushed	*Crushed*
Percent retained by 14-mesh screen	63.5	61.2
Percent retained by 30-mesh screen	21.4	23.8
Percent retained by 50-mesh screen	6.4	6.8
Percent retained by 100-mesh screen	2.9	3.5
Percent passing through 100-mesh screen	5.6	4.4

The chemical composition data are presented by plotting the alpha-cellulose content of each pulp against its Klason lignin content (Fig. 4). These data show that at a given lignin content no significant difference exists between the alpha-cellulose content of crushed

Table II. Fiber Classification—Beaten Pulp

	Uncrushed	*Crushed*
Percent retained by 14-mesh screen	57.8	39.1
Percent retained by 30-mesh screen	23.1	34.1
Percent retained by 50-mesh screen	7.4	11.1
Percent retained by 100-mesh screen	2.7	4.3
Percent passing through 100-mesh screen	8.9	11.4

and uncrushed pulp. This supports the conclusion that as far as chemical composition is concerned the pulps are identical and crushing does not expose any one particular wood component to excessive attack.

Before discussing the physical test data, the effect of the various treatments on fiber length differences between crushed and uncrushed pulps must be given

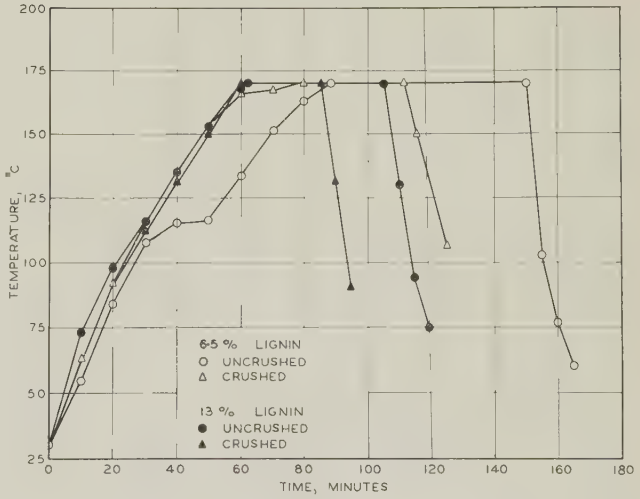


Fig. 3. Digester temperature as a function of cooking time

consideration. A Thwing Albert (Clark) classifier was used to classify a crushed and an uncrushed screened pulp sample of equal lignin content both before and after 20 min. beating in a Jokro mill. These values are recorded in Tables I and II.

Table I shows that the unbeaten pulps compare quite well. After beating, however, the retention of the crushed pulp by the 14-mesh screen has decreased by about 20% (Table II). The uncrushed pulp is apparently unaffected. The difference that would be expected in physical strength properties between crushed and uncrushed pulps as a result of this difference in average fiber length is impossible to accurately ascertain. This must therefore remain a questionable point. However, on the basis of what little work has been done on the effect of fiber length on handsheet strength properties (*6*), it seems reasonable to suppose that the difference indicated in Table II is not sufficient to produce more than minor differences in the pulp strength properties.

The physical strength data for crushed and uncrushed pulp beaten 20 min. in a Jokro mill have been correlated against the lignin content of the pulp (Figs. 5 to 10). In this manner comparisons can be made at equivalent chemical composition. The bonding strength data are presented in Table III.

Table III. Bonding Strength Data

% Lignin	V.V.P. Bonding Strength	
	Uncrushed pulp	Crushed pulp
6.5	5.653	5.825
9.4	6.787	...
12.9	...	6.935
13.2	4.449	...
18.1	...	5.201

A statistical evaluation of the data indicates that real and significant differences exist between crushed and uncrushed pulps in all physical properties with the exception of bonding strength and apparent density. The first significant item to be considered is the very definite decrease in zero span tensile strength (about 30%) from the uncrushed to the crushed pulp (Fig. 5). Although some doubt exists as to whether the zero span test is solely a measure of fiber strength, it is fairly well established that it is primarily affected by this property. The large drop in zero span tensile strength is thus accepted as conclusive evidence that the intrinsic fiber strength of the crushed pulp is less than that of the uncrushed pulp.

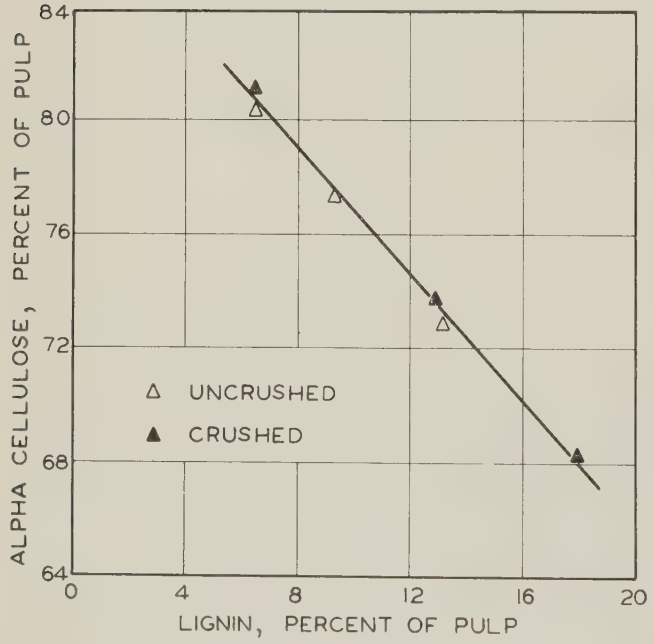


Fig. 4. Alpha-cellulose content as a function of lignin content

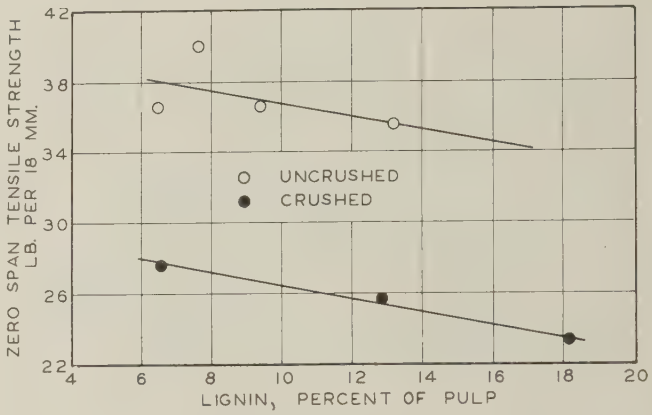


Fig. 5. I.P.C. zero span tensile strength as a function of Klason lignin content

Although the crushed pulp differs in burst, tensile, fold, and tear strength from the uncrushed, it has about the same V.V.P. bonding strength (*12*) and apparent density. With the exception of folding endurance these last two tests are the only ones of those carried out that are believed to be independent of inherent fiber strength. (The difference in folding endurance between pulps is not, as will be amplified later, a characteristic difference.) It thus follows that the only difference between the pulps is a matter of inherent fiber strength. This conclusion is further substantiated by the fact that the pulps do not differ in chemical composition at a given lignin content. This would tend to reduce differences in extent of bonding as well as the strength of individual bonds. Thus it may be said that the net effect of crushing wood which is subsequently cooked by the kraft process is to decrease the inherent fiber strength. No other effect is apparent.

Causal Factors

The following experiment was carried out in an effort to elucidate the factors causing the decrease in fiber strength. A sample of moist pulp produced from untreated spruce chips was compressed in a hydraulic press to a load of 25 tons. When released, the sample resembled a piece of masonite. This pulp was then slurried, beaten for 20 min. in a Jokro mill, and zero span data collected for the handsheets. There was no difference between the zero span strength of the pulp before and after compression.

This serves to illustrate that a compression load of 25 tons does not reduce the inherent fiber strength of a sample of unrestrained pulp fibers. Possibly a restraining of these fibers as occurs in the natural wood would make it possible for a compressive load to impair fiber strength. However, this seems doubtful for the following reason. Although it is easy to visualize a high compression load axially applied to a wood block causing damage to a region or regions of the fiber, it is

difficult to imagine all the fibers being uniformly degraded. Yet to achieve the observed decrease in zero span strength, degradation must be uniform. (If the fiber were merely damaged at several places along its

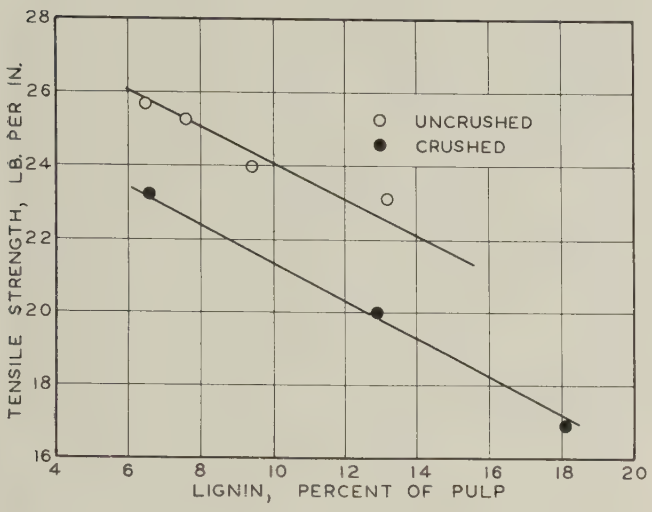


Fig. 6. Schopper tensile strength as a function of Klason lignin content

length, it would be a statistical occurrence that the zero span jaws would happen to span this weakness; and, hence, highly improbable that any marked decrease in strength would be observed.)

Thus, as a working hypothesis it is proposed that the crushing of the wood creates an environment for the kraft cooking liquor which favors a uniform degradation of the fibers. The kraft cooking liquor is, then, actually responsible for the decrease in inherent fiber strength.

Causal Mechanism

Mechanisms whereby mechanical treatment followed by chemical digestion could produce a decrease in the strength properties of the pulp have been suggested by Grogaard (*7*), Grondal (*8*), and Stone (*9*). On the basis of the contention of this paper that only inherent fiber strength is affected, the implication of these theories is that crushing results in increased chemical attack, thus reducing average chain length of the cellulose molecules. This in turn is reflected in a decrease in inherent fiber strength of the fibers. Viscosity measurements should thus indicate the decrease in pulp strength.

From the viscosity measurements made in this study, the decrease in average D.P. of the alpha-cellulose residue from uncrushed to crushed pulp of equal (6.5%) original lignin content was estimated to be from 1100 to 800. Since a good correlation has never been made between viscosity measurements and actual fiber strength, it is impossible to determine whether this difference in average D.P. could account for the large decrease in fiber strength as indicated by the zero span tensile values.

The following treatment is an extension of existing ideas and seems to be the most acceptable conjecture of the mechanism whereby weak pulp results from crushed wood. Compression or other mechanical action produces numerous planes of failure in the wood specimen. These failures normally occur in the middle portion of the secondary wall of individual fibers (*10*). The sketch of the fiber wall (Fig. 11) indicates micelle orientation and the failure region. In the undamaged fiber the outer layer of the secondary wall, which is made up of microfibrils oriented perpendicular to the fiber axis, forms a spiral sheath which contains the oppositely oriented microfibrils of the thick middle layer. Cooking liquor, as it diffuses through this middle layer, cannot penetrate crystalline regions, and the protective outer layer restrains any swelling tendency. Thus, damage to this critical area of the fiber by cooking liquor is kept at a minimum. If the protective layer is stripped away because of mechanical pretreatment, cooking liquor is capable of two modes of attack both of which will reduce fiber strength.

1. The cooking liquor will be able to induce swelling of the middle portion of the secondary wall which will effectively decrease the amount of crystalline area and expose more of the cellulose to degrading attack. This will reduce the average D.P. of the cellulose and show up as a decrease in the viscosity of the pulp.
2. Because of the heterogeneous nature of the middle section of the secondary wall, the swelling produced by the cooking liquor will set up stress concentrations. This will tend to distort the micelle orientation. Thus the alignment will be less parallel with the direction of the fiber axis. Any decrease in alignment parallel to the fiber axis will decrease the intrinsic fiber strength. This, however, will not show up as a decrease in pulp viscosity. Both these modes of attack probably occur. The extent to which one is dominant might possibly be tied up with wood species, extent of mechanical damage, and the type of chemical treatment afforded the wood.

The Physical Strength Data

The only difference between the crushed and the uncrushed pulps (assuming that the fiber length differences noted do not contribute significantly to physical strength differences) is one of inherent fiber strength.

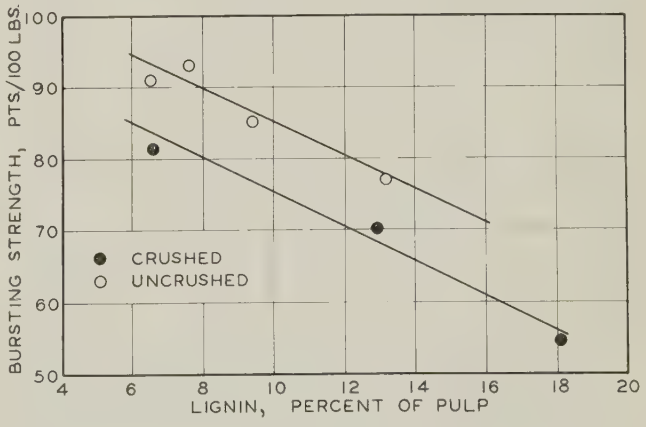


Fig. 7. Mullen burst strength as a function of Klason lignin content

Thus, the strength data collected can be viewed in the light of this single difference.

Zero Span Tensile Strength. The zero span tensile test is believed to be a fairly independent measure of inherent fiber strength. Although an exhaustive analysis of the test has not been made, no adequate

proof exists indicating that such items as degree of bonding or average fiber length have any great effect on the zero span value.

The zero span values plotted against lignin content for both crushed and uncrushed pulps (Fig. 5) decrease with increasing lignin content. The only effect of the

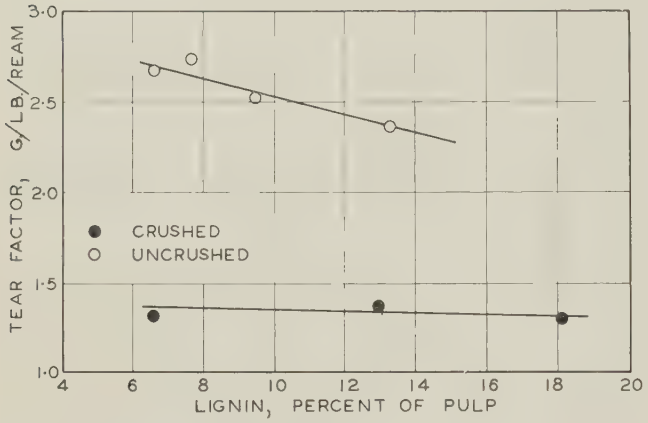


Fig. 8. Elmendorf tear strength as a function of Klason lignin content

lignin should be to decrease the amount of cellulose present in the cross section. Thus, the data corrected for basis weight and alpha-cellulose content should be independent of the lignin present. The results of this calculation* (Fig. 12) appear to substantiate this reasoning.

Tensile Strength. The difference between the tensile strength of crushed and uncrushed pulps of various lignin contents (Fig. 6) can be analyzed in relation to the zero span values. For instance, if the tensile test were independent of fiber strength, one would not expect the tensile strengths for the crushed

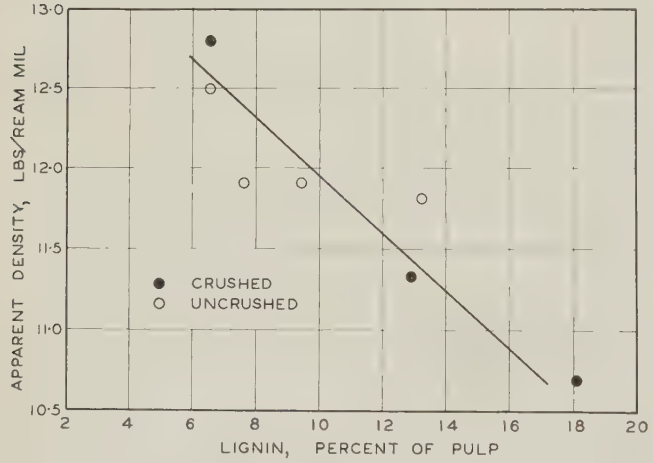


Fig. 9. Apparent density as a function of Klason lignin content

and uncrushed pulps to differ. Conversely, if the tensile strength were totally dependent on fiber strength, the drop in tensile strength should be the same as the decrease in zero span tensile strength. Thus, a comparison of the decrease in tensile strength to that of the zero span strength from uncrushed to crushed pulp gives a rough quantitative measure of the percentage of fibers that actually broke during the tensile test. For this study the figure was about 15%. As an order of magnitude, then, for a moderately beaten spruce kraft pulp (about 60% of maximum tensile strength developed) only about 15% of the fibers present on the line of failure actually break; the rest pull out. An analysis of the tensile test should give an indication of the significance of this result.

Consider an unruptured predetermined line of tensile failure. A fiber lying across this line can either break or pull out. If the fiber is sufficiently well bonded on either side of the line of rupture, it will break. Thus a critical fiber length exists represented by that fiber which when located symmetrically across the line of failure (i.e., equal amount of bonding on each side) will just break. The longer the fiber relative to this critical length the more latitude exists in the positioning of a fiber which will break under tensile load. Since the

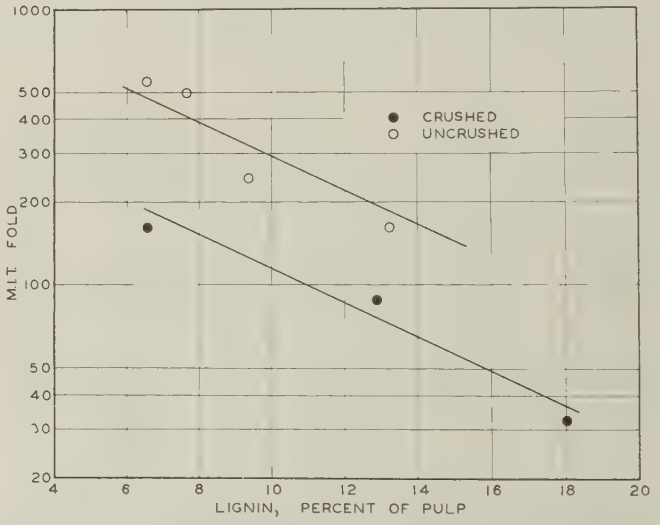


Fig. 10. M.I.T. folding endurance as a function of Klason lignin content

ability of a fiber to withstand a tensile load decreases as the fiber becomes less parallel with the direction of application of that load, it follows that the critical length will be dependent on orientation. Nevertheless, long fibers will have a much better chance of being so located as to produce breakage, while shorter fibers will tend to pull out. Thus, the indication is that fiber strength has a variable influence on tensile strength depending on the actual fiber length distribution and the extent of bonding. These latter two properties should be carefully considered before making a prediction as to the contribution of fiber strength to tensile strength in a given situation.

Burst Strength. Burst strength has been correlated with the product of tensile strength and the square root of stretch. On the basis of the results of a previous section (Effect of Crushing), it seems reasonable to assume that no great difference exists between the stretch value of the uncrushed and the crushed pulp. Thus, the difference in burst strength between the two pulps should be directly proportional to their difference in tensile strength. The percentage

* Zero span factor = $\frac{\text{Zero span tensile strength}}{\text{(basis weight) (Alpha cellulose content)}}$

decrease in tensile strength from uncrushed to crushed pulp at 10% lignin content (from Fig. 6) is 11.2%. The corresponding decrease in the burst strength (from Fig. 7) is 11.8%. This give credence to the above reasoning.

Tear Strength. Two things are noteworthy with regard to the relative tear strength of the crushed and uncrushed pulps (Fig. 8). First, a marked decrease in tear strength results from crushing. Second, it is the only physical property in which the actual difference appears to decrease with increasing lignin content. This is a result of the apparent independence of the tear strength of the crushed pulp to changes in lignin content.

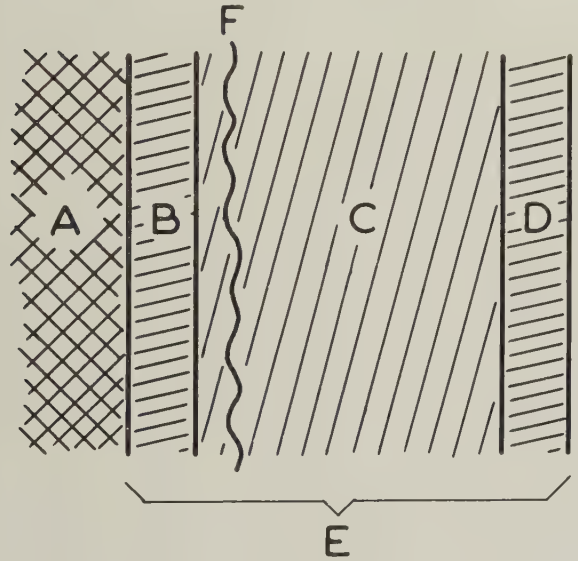
The tearing strength of a test specimen is qualitatively described by the following relationship (*11*):

$$T = mX + nY$$

where

T = the work required to tear the specimen (tear strength).
m = the number of fibers that break.
X = the average work required to break a single fiber.
n = the number of fibers that pull out.
Y = the average work required to pull out a single fiber.

Because of the distances involved, considerably more work is done in pulling out a fiber than in breaking it. Thus, the nY factor normally contributes most heavily to the tear strength value. In going from an uncrushed to a crushed pulp, Y remains unchanged while a distinct decrease occurs in X. Since the individual fibers have been weakened, a shift will occur from fibers that pull out to ones that break (i.e., m increases at the expense of n). The net effect of these two changes will be to decrease nY without producing anywhere near the same magnitude of increase in mX. Thus, the tear



A—compound middle lamella. B—outer layer. C—middle layer. D—inner layer. E—secondary wall. F—failure plane.

Fig. 11. Cell wall of the pulp fiber

strength would be expected to decrease in some relation to the loss in fiber strength.

The relative independence of the tear strength of the crushed pulp from lignin content seems to indicate that such a wholesale shift has occurred from fibers that pull out to fibers that break, that changes in bonding resulting from increased lignin content do not materially affect the tear value.

Folding Endurance. The evidence submitted (Fig. 10) appears to indicate that folding endurance

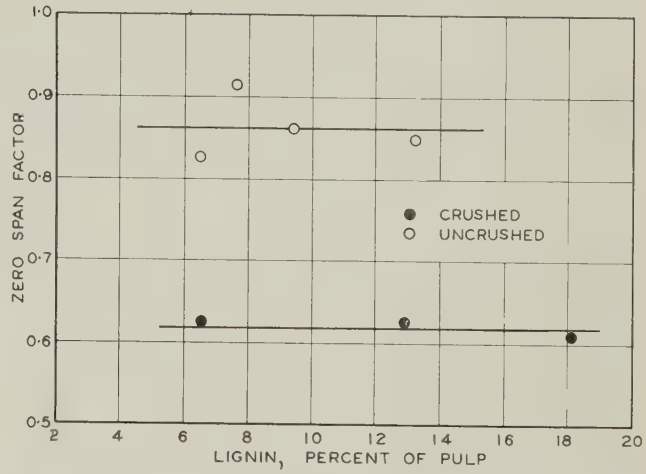


Fig. 12. Zero span factor as a function of Klason lignin content

is a reflection of fiber strength. However, the results of a simple experiment disprove this apparent conclusion.

A test specimen whose average folding endurance and zero span strength were known was placed in the M.I.T. fold tester and folded to within a few folds of the average failure. The machine was then stopped and the test strip removed. The effect of this treatment was to produce a line across the test specimen where the optical properties had been changed. The test strip was mounted in the zero span jaws so that the failure occurred along this line. No decrease in zero span strength had occurred. This is accepted as adequate proof that inherently folding endurance is quite independent of fiber strength.

Since the M.I.T. test requires a standard tension of 1 kg. in the test strip, the difference in the recorded values of folding endurance between crushed and un-

Table IV. Corrected Folding Endurance Values

	Tensile strength, lb./in.	*Tensile strength ratio*	*Applied tension load, gr.*	*Average fold value*
Uncrushed	25.1	0.85	1000	488
Crushed	21.3	...	850	504

crushed pulp could be due to the difference in the ability of the two pulps to withstand this tension load. To check this hypothesis, the folding endurance of an uncrushed and a crushed pulp of equal (6.5%) lignin content were compared by adjusting the tension load of the fold test in the ratio of the respective tensile strengths. The data from this experiment are presented in Table IV.

This is further evidence supporting the view that the M.I.T. fold test produces a weakening of the test area through the rupture of bonds until a sufficient number have been broken to allow failure under a load of 1 kg.

Thus, to be really meaningful, a fold test should take into account variations in tensile strength produced by differences in fiber strength by altering the tension load. Since at the present time it is impossible to determine the contribution of fiber strength to tensile strength, it becomes immediately apparent that the use of the fold test to compare pulps of different inherent fiber strengths is of questionable value.

V. V. P. Bonding Strength. The results of this study suggest that the V.V.P. bonding test is independent of fiber strength. With this established it seems that more interest should be directed toward this test as an efficient tool in basic research.

CONCLUSION

Interpretation of tensile, burst, tear, and fold data varies with each type of paper tested. It is essential to recognize this fact, particularly in making comparisons between different stocks. On a fundamental level these tests can be very misleading and should be carefully considered before being incorporated into an experimental program.

On the other hand, the work done in this study points to the zero span tensile test and the V.V.P. bonding test as potentially valuable tools. However, much fundamental work is required (particularly in the case of the V.V.P. test) before either test can be utilized in the most effective manner.

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Cold Soda Pulping of Southern Oaks, Sweetgum, and Cottonwood

KENTON J. BROWN

Batch and continuous cold soda pulping methods developed at the U. S. Forest Products Laboratory were used to pulp several southern hardwoods. Pulping characteristics were determined, and the properties of pulps made from these woods were compared. A mixture of two red oak species, water oak (*Quercus nigra* L.) and willow oak (*Quercus phellos* L.), was pulped under various conditions of pressure, time, temperature, and chemical concentration to produce pulps having yields in a range of from 82 to 96%. Pulp strength was increased by increasing the time, temperature, or pressure of the caustic soda treatment. Increasing the caustic soda solution concentration above 35 g.p.l. lowered the yield and brightness of pulp made at room temperature but had little effect on its strength, which was slightly above that of softwood groundwood. The brightness of pulp bleached in a single stage with 10% available chlorine in the form of calcium hypochlorite decreased about 5 percentage points as the caustic soda steeping temperature was increased in a range of from 25 to 89°C. Pulp suitable for use in printing paper as a substitute for southern pine groundwood was made by treating a mixture consisting of several hardwoods, including red and white oaks, gums, and poplar, with caustic soda solutions at room temperature in a digester for either (1) 2 hr. at atmospheric pressure or (2) 30 min. at 150 p.s.i. Sweetgum (*Liquidambar styraciflua*) cold soda pulp was slightly stronger than southern pine groundwood but darker in color. Cold soda pulp made from cottonwood (*Populus deletoides*) was somewhat stronger and lighter in color than sweetgum cold soda pulp. Corrugating boards produced from cold soda pulps made in the continuous system from mixtures of (1) water oak and willow oak and (2) red oak and white oak had Concora values of 54.1 and 51.3 lb., respectively. A somewhat stronger board made from cottonwood cold soda pulp had a Concora value of 77.4 lb.

THE importance of hardwoods to the paper industry in the southern States is illustrated by statistics found in the Timber Resources Review of 1958. According to data obtained in 1952, the net volume of hardwoods growing in the south exceeded that of the softwoods by 30% (*1*). The report also showed that hardwood timber in this section was growing 62% faster than it was being cut.

One possible use for more hardwood in the south is in the production of high-yield semichemical pulps that are suitable for use as low-cost partial substitutes for southern pine groundwood and sulphate pulps and for other uses. The commercial success of the cold caustic soda semichemical process in pulping hardwoods during the last 2 years had proved that this method, first developed at the U. S. Forest Products Laboratory in 1949, is a satisfactory means of utilizing a raw material of which there is an abundance, at the same time providing high-yield pulps with improved properties. The fundamental steps in this process include: treating chips with a sodium hydroxide solution, draining off excess liquor, and fiberizing the softened chips in a disk mill. Cold soda pulps being made by several mills in the United States, as well as mills in Tasmania and Italy, are used in the manufacture of corrugating board, printing papers, and tissue. There are also indications that cold soda pulps can be used satisfactorily in other products, such as toweling and various types of paperboard.

Although the cold soda process is already being used

KENTON J. BROWN, Chemical Engineer, Forest Products Laboratory, maintained at Madison, Wis., in cooperation with the University of Wisconsin, Forest Service, U. S. Department of Agriculture.

commercially in the southern states to produce groundwood-type pulps from the oaks and gums, it was important to obtain more information on the pulping characteristics of these and other southern hardwoods, which should lead to improved pulp quality and wider use. Experiments have shown that the oaks and gums respond more slowly to treatments with caustic soda at room temperature and pressure, conditions commonly used in this process, than do hardwoods of lower density and lignin content, such as aspen and birch. Cold soda pulps produced under mild conditions from the more dense hardwoods are generally weaker and darker in color than those made from the more easily pulped hardwoods.

Methods of accelerating the penetration of caustic soda liquor into chips (preevacuation, hydrostatic pressure, and mechanical compression) have shown promise in shortening the time and improving the uniformity of treatment in pulping aspen by this process (*2*). One of the purposes of the experiments reported here was to determine the possibilities of using these forced-penetration methods for improving the quality of cold soda pulps made from various mixtures of southern oaks and gums. Much of the work was done on a mixture of water oak and willow oak, two species of the red oak group found in the West Gulf Region.

Some of these experiments were designed to determine the possibility of increasing the strength of oak cold soda pulp by increasing the treating temperature above the usual 25°C. Darker pulps were expected as a result of the higher temperature, but it was not known whether or not they would be more difficult to bleach. Another important point considered was that, if stronger and perhaps stiffer pulps could be made from oak by using higher treating temperatures, they very likely would be more suitable than the ordinary pulp for making corrugating medium where the color is not a serious matter.

This study included:

(a) Preliminary batchwise pulping experiments on the mixture of water oak and willow oak using preevacuation and hydrostatic pressure impregnation conditions at various temperatures, caustic soda concentrations, and treating times for comparison with standard cold soda steeping at atmospheric pressure.

(b) Continuous pulping trials in a roll-type mill (*3*) to determine the effects of caustic soda concentration on the pulping characteristics of sweetgum.

(c) Pilot-scale trials in batch and continuous equipment to compare the cold soda pulping characteristics of sweetgum, cottonwood, and mixtures of southern oaks.

(d) Comparison of properties of corrugating boards made from cold soda pulps produced from cottonwood, the mixture of water and willow oak, and a mixture of red and white oaks.

(e) Small-scale bleaching tests, using calcium hypochlorite to determine effects of the temperature and caustic soda concentration during pulping on the brightness and opacity of the bleached pulps.

EXPERIMENTS

Cold soda pulping trials were made on three mixtures of hardwoods and on two individual hardwoods. Peeled pulpwood was used in all of the experiments. Except as noted, chips produced in a laboratory chipper were about $^1/_2$ in. long in the fiber direction. Oversized and undersized materials were removed from the chips by passing them over vibrating screens and accepting the fraction that passed through a $1^1/_8$-in. screen and was retained on a $^1/_4$-in. screen.

Water oak and willow oak pulpwood logs obtained from southwestern Louisiana averaged about 7 in. in diameter and were similar in density, about 37 lb. per cu. ft. on the basis of weight when oven dry and volume when green. The average age of the logs was 26 yr. The water and willow oak grew at the average rates of 0.30 and 0.24 in. in diameter per year, respectively. Chips prepared from these woods were mixed in the proportion of 4 volumes of water oak to 1 volume of willow oak and stored in moistureproof containers, so that their moisture content, which was about 30%, remained almost constant throughout the trials.

Freshly cut cottonwood, red oak, and white oak pulpwood logs received from the lower Mississippi Valley region varied from 5 to 8 in. in diameter. A mixture of the oaks, prepared by mixing 1 volume of red oak chips with 2 volumes of white oak chips, had a moisture content of 31%. The cottonwood chips had a moisture content of 47%.

A mixture of chips prepared commercially from hardwoods in the Southwest Region contained approximately equal parts of (1) red oak, (2) white oak, (3) chestnut oak, and (4) a group of less dense hardwoods including several gums and poplar. The average moisture content of this mixture during the pulping trials was 25%. Sweetgum chips prepared from pulpwood obtained in the West Gulf Region had an average moisture content of 50%.

Pulping

Preliminary Trials. Preliminary cold soda treating experiments on the mixture containing 80% of water oak and 20% of willow oak were made in stainless steel tumbling autoclaves of 0.8-cu.-ft. capacity, which held 9 lb. of chips on the moisture-free basis. The conditions and results of these pulping trials are given in Table I. A reference treatment was made under atmospheric conditions, using a liquor-to-wood ratio of about 4 to 1. Hydrostatic pressure treatments were made by placing 15 lb. of pneumatic pressure per square inch in a reservoir of caustic soda liquor that was connected to the autoclave containing the chips. The liquor-to-wood ratio during the hydrostatic pressure treatments was 5 to 1 (excluding the excess liquor left in the reservoir). In one trial, a vacuum of 26.5 in. of mercury was drawn on the chips before the liquor was introduced under a hydrostatic pressure.

After the caustic soda treatment, the chips were drained free of liquor and weighed to determine the amount of liquor absorbed. They were then immediately fiberized to a coarse pulp in an 8-in. diam., single-rotating disk mill. The clearance between the plates in the mill was set at approximately 0.005 in. before each fiberizing run, so that the motor was drawing 6 amp. of current with a constant flow of water between the plates (3.0 g.p.m.) to produce a consistency between the plates of about 2%. The electrical energy consumed was read on a watt-hour meter and used as an

Table I. Conditions and Results of Batch Cold Soda Pulping Trials on a Mixture Consisting 80% of Water Oak and 20% of Willow Oak by Volume

Treatment no.	Temperature, °C.	Time, hr.	Sodium hydroxide concentration,[a] g.p.l.	Liquor absorbed by chips (original wet wood basis), %	Sodium hydroxide used[b] (original moisture-free wood basis), %	Fiberizing[c]: Energy consumed (per ton of air-dry pulp), hp.-days	Fiberizing[c]: Pulp freeness (Canadian Standard), ml.	Pulp yield, %
				Atmospheric Pressure				
3362	29	2	33.7	51.7	7.7	40.1	620	91.6
				Hydrostatic Pressure at 150 p.s.i.				
3367	25	0.5	34.4	59.1	3.90	34.6	595	94.1
3374	25	1	34.2	67.8	7.46	29.5	650	92.8
3363	25	2	35.1	58.6	8.98	26.1	605	92.0
3384	25	2[d]	35.6	64.0	8.18	25.7	720	88.9
3368	25	4	35.0	63.2	10.26	22.2	675	89.8
3363	25	2	35.1	58.6	8.98	26.1	605	92.0
3365	41	2	35.1	60.5	9.42	23.3	635	92.8
3371	60	2	34.6	60.6	9.93	20.7	705	88.9
3373	65[e]	1	34.1	..	7.08	24.6	650	89.1
3383	89	2	35.5	51.2[f]	10.20	14.9	745	81.6
3382	24	2	0	52.0	0	32.7	655	96.1
3375	25	2	7.4	63.4	2.75	42.2	560	95.6
3366	25	2	14.7	57.7	5.42	37.5	580	93.7
3398	25	2	24.5	63.6	7.02	28.7	..	91.5
3363	25	2	35.1	58.6	8.98	26.1	605	92.0
3369	26	2	77.8	59.0	10.90	19.6	635	90.7
3372	60	2	6.4	49.2	2.85	34.4	600	94.4
				Preevacuation and Hydrostatic Pressure at 150 p.s.i.				
3364	27	2	34.9	64.1	9.87	24.8	625	92.8

[a] Calculated on the basis of all water in the system, including that in the chips.
[b] Includes all of the chemical consumed by reaction, plus that left unconsumed in the chips after treatments made in an 0.8-cu.-ft. autoclave.
[c] Conducted in an 8-in. single-rotating disk mill under constant conditions (0.005-in. plate clearance and 2% consistency) using plate pattern no. 6946.
[d] Treated chips were washed for 1 hr. before fiberizing.
[e] Chips were presteamed at atmospheric pressure for 0.5 hr.
[f] This value is low because of an unavoidable loss of weight by evaporation after treating.

indication of the amount of chip softening afforded by the caustic soda treatment.

As shown in Table I, increasing the pressure during a 2-hr. steep at room temperature from 0 to 150 p.s.i. increased by 15% the amount of liquor absorbed by the chips, increased the amount of caustic soda used about 15%, and decreased by the fiberizing energy requirements 35%. Removing the air from the chips prior to the caustic soda steep at 150 p.s.i. caused further increases in liquor absorption and chemical consumption of 13 and 10%, respectively, and an additional decrease in fiberizing energy of 5%. The use of hydrostatic pressure and vacuum did not seem to have any significant effect on pulp yield.

Increasing the time of a room-temperature, hydrostatic pressure treatment made with a 35 g.p.l. caustic soda solution in a range of from 0.5 to 4 hr. (1) increased the amount of chemical used in a range of from 3.9

Table II. Physical Properties of Batch Cold Soda Pulps Prepared from a Mixture Consisting 80% of Water Oak and 20% of Willow Oak by Volume

Treatment no.	Cold soda pulping conditions: Temperature, °C.	Time, hr.	Sodium hydroxide concentration, g.p.l.	Pulp properties (at Canadian Standard freeness of 200 ml.)[a]: Beating time, min.	Burst factor	Tear factor	Breaking length, m.	Density, g./cc.	Unbleached brightness[b] (G.E. equivalent), %
				Atmospheric Pressure					
3362	29	2	33.7	44	18.7	61.7	3900	0.43	42.5
				Hydrostatic Pressure at 150 p.s.i.					
3367	26	0.5	34.4	53	13.2	48.5	2910	0.40	41.2
3374	25	1	34.2	39	16.5	52.4	3000	0.43	..
3363	25	2	35.1	64	23.1	62.5	4550	0.50	42.3
3384	25	2[c]	35.6	55	22.6	53.2	3800	0.46	43.6
3368	25	4	35.0	54	26.4	65.6	4840	0.49	41.2
3363	25	2	35.1	64	23.1	62.5	4550	0.50	42.3
3365	41	2	35.1	60	24.2	61.0	4780	0.48	41.6
3371	60	2	34.6	69	25.9	64.9	4820	0.51	37.7
3373	65[d]	1	34.1	69	26.4	63.3	4890	0.49	35.4
3383	89	2	35.5	76	34.7	57.1	5600	0.58	33.8
3382	24	2	0	60	2.8	15.6	800	0.33	41.8
3375	25	2	7.4	28	2.2	18.0	830	0.32	41.6
3366	25	2	14.7	54	10.5	42.2	2240	0.38	44.1
3363	25	2	35.1	64	23.1	62.5	4550	0.50	42.3
3369	26	2	77.8	54	24.2	64.1	4580	0.50	39.4
3372	60	2	6.4	56	7.2	34.4	1470	0.34	42.1
				Preevacuation and Hydrostatic Pressure at 150 p.s.i.					
3364	27	2	34.9	80	26.4	62.5	4960	0.51	42.4

[a] Developed by refining in a 1.5-lb. test beater.
[b] After refining to a freeness (Canadian Standard) of approximately 300 ml. in an 8-in. disk mill.
[c] Treated chips were washed for 1 hr. before fiberizing.
[d] Chips were presteamed at atmospheric pressure for 0.5 hr.

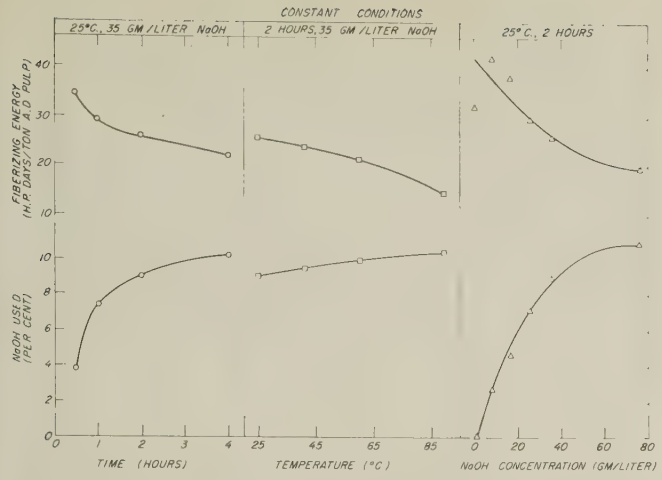

Fig. 1. Relations between the amount of caustic soda used (moisture-free wood basis), fiberizing energy consumption, and treating time, temperature, and chemical concentration in the caustic soda treating of a mixture consisting 80% of water oak and 20% of willow oak chips at a constant hydrostatic pressure of 150 p.s.i.

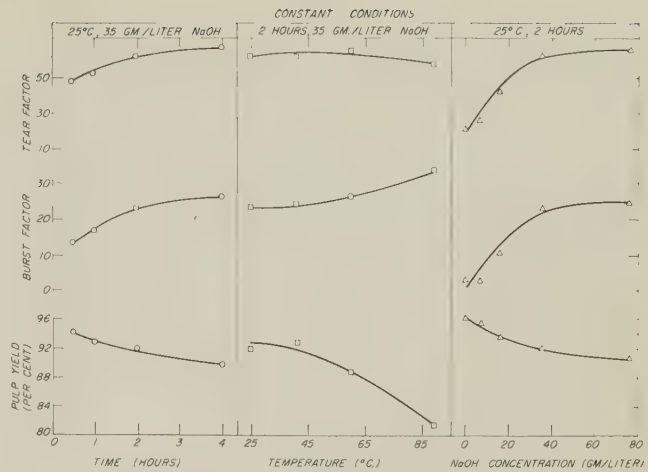

Fig. 2. Relations between pulp yield, burst, and tear factor at 200 ml. Canadian Standard freeness, and treating time, temperature, and chemical concentration in the caustic soda treating of a mixture consisting 80% of water oak and 20% of willow oak chips at a constant hydrostatic pressure of 150 p.s.i.

to 10.3% (moisture-free wood basis), (2) decreased the pulp yield in a range of from 94.1 to 89.9%, and (3) decreased the fiberizing energy requirements about 35%. These results are illustrated by the curves in Figs. 1 and 2.

Most of the tests were made at room temperature (approximately 25°C.), but, during one series of

Under constant treating conditions of 2 hr. at room temperature and 150 lb. of pressure per square inch, increasing the concentration of the caustic soda solution in a range of from 7.4 to 77.8 g.p.l. resulted in (1) increasing the amount of chemical used in a range of from 2.8 to 10.9% (moisture-free wood basis), (2) decreasing the pulp yield in a range of from 95.6 to 90.7%

Table III. Conditions and Results of Cold Soda Pulping of Several Southern Hardwoods in Pilot-Plant Equipment

Treatment No.	Method[a]	Treating conditions: Temperature, °C.	Time, hr.	Pressure, p.s.i.	Sodium hydroxide concentration,[b] g.p.l.	Sodium hydroxide used[c] (moisture-free wood basis), %	Pulp yield, %	Total energy consumed[d] (per ton of air-dry pulp), hp.-days	Pulp properties: Freeness (Canadian Standard), ml.	Burst factor	Tear factor	Breaking length, m.	Density, g./cc.	Brightness (GE equivalent), %
						Oak Mixture[e]								
4222	Batch	80	2	150	50.0	13.1	86.9	28.6	495	12.7	53.2	1850	0.42	38.0
KM157	Continuous	58	..	..	59.6	12.8	..	29.0	410	13.2	54.7	1980	0.41	42.0
						Hardwood Mixture[f]								
4210	Batch	24	2	0	30.0	9.4	92.0	31.4	175	13.2	50.8	2500	0.47	40.8
4211	Batch	23	2	0	50.0	12.8	91.9	26.7	235	13.2	50.8	2320	0.47	40.2
4212	Batch	21	0.5	150	30.0	9.0	93.5	34.1	150	14.3	45.4	2525	0.46	39.5
4221	Batch	26	0.5	150	50.0	12.7	89.2	27.8	275	17.1	55.5	3420	0.52	38.5
						Sweetgum								
4021	Batch	26	2	0	54.0	12.9	90.1	22.7[g]	400	14.3	57.1	2850	0.50	40.8
KM172	Continuous	28	..	..	51.5	13.7	91.7	38.6	185	16.5	56.3	3010	0.46	41.1
KM181	Continuous	29	..	..	33.9	8.5	92.4	38.9	240	9.4	53.9	2200	0.48	42.6
KM173	Continuous	29	..	..	20.3	4.1	93.9	49.3	110	7.2	33.7	1700	0.40	42.0
						Cottonwood								
4118	Batch	30	2	0	57.2	9.4	91.3	..	500	21.5	80.5	3410	0.56	51.9

[a] Batch treatments were made in a 14-cu.-ft. digester. Continuous treatments were made in a roll mill having a 16-in. diam., 4-ft. long cylinder, using a linear pressure on the inside roll of 120 lb. per in. and a cylinder speed of 260 r.p.m. Treated chips were stored approximately 0.5 hr. before screw pressing.
[b] Actual liquor analysis (does not include the moisture in the chips).
[c] Includes all of the chemical consumed by reaction plus that left uncomsumed in the treated chips.
[d] Includes all of the energy consumed during the various stages of fiberizing and refining (roll mill, screw press, and disk mill).
[e] Mixture contained 80% of water oak and 20% of willow oak, by volume.
[f] Mixture contained approximately equal parts of (1) white oak, (2) red oak, (3) chestnut oak, and (4) a group of less dense hardwoods including poplar and gum.
[g] Chips were not screw pressed before fiberizing in a disk mill.

treatments, temperatures of 41°, 60°, and 89°C. were maintained by indirectly heating the autoclave with steam. As shown in Table I and in Figs. 1 and 2, increasing the treating temperature in this range during a 2-hr. treatment at 150 p.s.i. (1) increased the amount of chemical used about 15%, (2) decreased the pulp yield in a range of from 92 to 81.6%, and (3) decreased the fiberizing energy about 45%.

and (3) decreasing the fiberizing energy requirements 53%, as shown in Table I and Figs. 1 and 2.

Preliminary continuous cold soda pulping trials were made on sweetgum chips to determine the effects of chemical concentration on pulp yield and quality. The trials were made by feeding chips into a roll-type refining mill where they were repeatedly compressed between a revolving cylinder and a rotating roll and

retained in the presence of the caustic soda solution for about 30 sec. before being discharged in the form of a partially fiberized pulp. About 100 lb. (moisture-free basis) of chips were treated in each of these trials.

The chips were fed into the roll mill at the rate of about 300 lb. per hr. The solids content of the pulp material discharged from the roll mill varied between 20 and 27%. The material discharged from the roll mill was held for 30 min., then pressed in a three-section, 7-in. diam. screw press to a dryness of about 51%. The pressed material was fiberized and refined in a double pass in a 36-in. diam. double-rotating disk mill. Other conditions and results of these tests are given in Table III.

Results of continuous trials made on sweetgum at room temperature indicated that increasing the caustic soda solution concentration in a range of from 20.3 to 51.5 g.p.l. increased the amount of chemical used in a range of from 4.1 to 13.7% (moisture-free wood basis) and decreased the pulp yield about 2 percentage points, as shown in Table III. Another result of increasing the amount of caustic soda applied to the chips was to decrease the total amount of fiberizing energy consumed by the roll mill, screw press, and disk mill in a range of from 49.3 to 38.6 hp.-day per ton of air-dry pulp.

Pilot-plant Pulping. Quantities of cold soda pulps needed for subsequent corrugating board trial runs were made by treating the mixture of water oak and willow oak chips with caustic soda solutions (1) batchwise in a 14-cu. ft., steam-jacketed digester, and (2) continuously in the roll mill, using optimum conditions established in preliminary trials and given in Table III. Chips treated both ways were screw pressed, fiberized in a single pass through the 36-in. disk mill, screened through 0.012-in. slotted flat screens, and dewatered on a wet machine. Sweetgum and cottonwood cold soda pulps were prepared in a similar manner by batch treatments in the 14-cu. ft. digester (Table III).

A series of pilot plant batch cold soda treatments were made on the mixture containing approximately equal parts of (1) red oak, (2) white oak, (3) chestnut oak, and (4) a group of gums and poplar to determine the effect of applying hydrostatic pressure during a room-temperature steep in caustic soda. At a given caustic soda concentration of either 30 or 50 g.p.l., approximately the same results, with respect to chemical consumption, pulp yield, and energy consumption, were obtained from treatments made under 150 p.s.i. of hydrostatic pressure for 30 min. as were obtained from those made under atmospheric conditions in 2 hr. (Table III).

Conditions and results of continuous pulping trials made on cottonwood and a red and white oak mixture in the preparation of pulps used in making corrugating boards are given in Table IV. In comparison with the mixture of water oak and willow oak, the amounts of caustic soda used in making the pulps from these species were about in the same range.

Pulp Properties

Pulps prepared from the mixture of water oak and willow oak chips treated in the autoclave were submitted to strength development in a 1.5-lb. test beater. Strength tests were made on the pulps in accordance with TAPPI Standard methods, except that 55-lb. (ream of 500 sheets, 25 by 40 in.) sheets were used. A portion of each pulp was also refined to a freeness of approximately 300 ml. (Canadian Standard) by recycling it through the 8-in. disk mill. The pulps refined in this manner were tested for brightness and used in subsequent bleaching trials. The results of these physical tests are given in Table II.

In comparison with a 2-hr. steep made on the mixture of water oak and willow oak at atmospheric conditions and a caustic soda concentration of 35 g.p.l., applying (1) a hydrostatic pressure of 150 p.s.i. and (2) a vacuum before the hydrostatic pressure treatment increased the bursting strength of the pulp at a freeness of 200 ml. (Canadian Standard) about (1) 25% and (2) 40%, respectively, without having any significant effect on its tearing resistance and brightness. When the time at room temperature of a hydrostatic pressure treatment made with a 35 g.p.l. solution was increased in a range of from 0.5 to 4 hr., the bursting strength was doubled and the tearing resistance of the pulp increased 35%, as shown in Table II and Fig. 2, without affecting its brightness. At a constant caustic soda concentration of 35 g.p.l., increasing the temperature in a range of from 25 to 89°C. during a 2-hr. hydrostatic pressure treatment increased the bursting strength of the pulp 50% but decreased its brightness in a range of from 42.3 to 33.8% (Table II and Fig. 2 and 3). The effect of

Table IV. Properties of Corrugating Boards Made from Cold Soda Pulps Produced Continuously from Southern Hardwoods

	Pulping conditions[a]				*Board properties*								
Treatment No.	*Temperature, °C.*	*Sodium hydroxide concentration, g.p.l.*	*Sodium hydroxide used (moisture-free wood basis), %*	*Total fiberizing energy consumed (per air-dry ton of pulp), hp.-days*	*Machine run no.*	*Headbox freeness (Canadian Standard), ml.*	*Weight (per 1000 sq. ft.), lb.*	*Density, g./cc.*	*Bursting strength (Mullen), pt.*	*Tearing resistance (average), g.*	*Tensile strength, lb. per in. of width*	*Average ring compression,[b] lb.*	*Concora,[c] lb.*
					Water and Willow Oak Mixture[d]								
KM157	58	59.6	12.8	29.0	4960	360	26.1	0.50	33.1	71	30.0	50.3	54.1
					Cottonwood								
KM127	40	59.2	11.9	19.4	4581	400	26.0	0.64	47.8	73	36.0	48.5	77.4
					Red and White Oak Mixture[e]								
KM128	42	87.8	11.4	16.3	4585	415	26.0	0.47	28.8	66	24.4	49.9	51.3

[a] Constant conditions for all continuous trials in a roll mill having a 16-in. diam., 4-ft. long cylinder were: cylinder speed, 260 r.p.m.; linear pressure on roll, 120 lb. per in.
[b] Test specimen of 1/2 by 6 in.
[c] Test specimen of 10 A-flutes, 1/2-in. wide.
[d] Mixture contained 4 parts of water oak and 1 part of willow oak, by volume.
[e] Mixture contained 1 part of red oak and 2 parts of white oak, by volume.

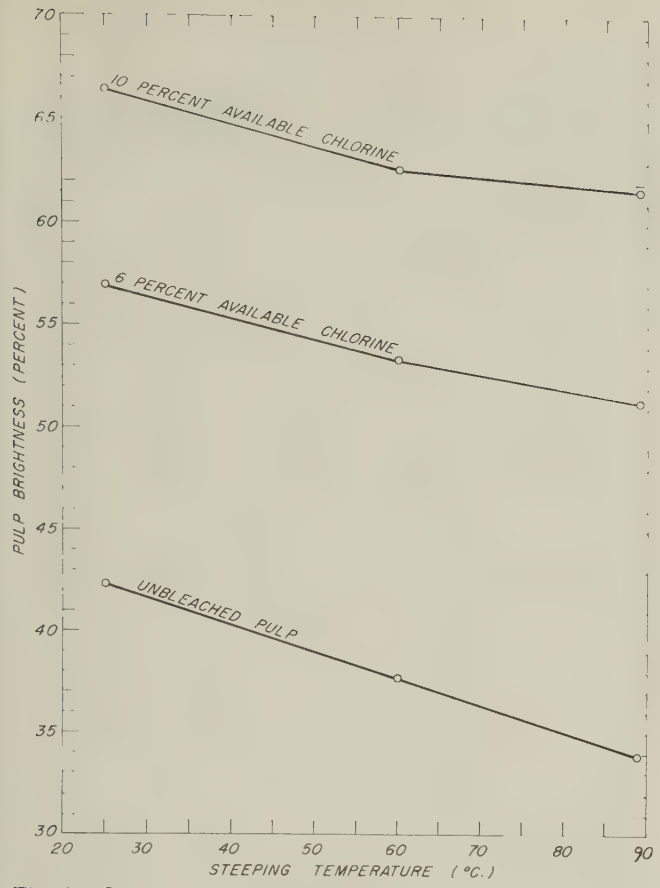

Fig. 3. Influence of caustic soda pulping temperature on the brightness of unbleached and hypochlorite-bleached cold soda pulps prepared from a mixture consisting 80% water oak and 20% of willow oak

treating temperature on the properties of the bleached pulp is discussed later.

The effects of increasing the caustic soda solution concentration in a range of from 7.4 to 77.8 g.p.l. at constant treating conditions of 2 hr. at room temperature and 150 p.s.i. were (1) to increase the pulp's burst and tear factors approximately 11 and 3.5 times, respectively, and (2) to lower its brightness about 3 percentage points (Table II). As shown by the curves in Fig. 2, the increase in pulp strength between chemical concentrations of 35 to 78 g.p.l. were only slight. A mechanical pulp (no. 3382) made under the same conditions but with water only was no lighter in color than pulps made with caustic soda and its low strength properties were about the same as those of the cold soda pulp made with a 7.4 g.p.l. solution. An attempt to improve the results obtained with a low-concentration caustic soda treatment by increasing the temperature to 60°C. (no. 3372) resulted in somewhat higher pulp strength without loss in brightness. The effect of concentration in pulping this oak mixture is also discussed in the section of this report on bleaching.

The results of studying other variables in the pulping of the water oak-willow oak mixture were: (1) washing the chips after the caustic soda treatment and before fiberizing (no. 3384) Tables I and II increased the brightness of the unbleached pulp 1.3 percentage points but decreased both the tearing resistance and tensile strength of the pulp; and (2) steaming the chips for 0.5 hr. at atmospheric pressure prior to a 1-hr. caustic soda treatment at 65°C. produced a pulp as strong and at the same yield but 2.2 percentage points lower in brightness than that produced by a 2-hr. treatment at 60°C. without presteaming.

Results of continuous trials made on sweetgum in the roll mill at room temperature showed that increasing the caustic soda concentration in a range of from 20.3 to 51.5 g.p.l. approximately doubled the strength properties of the pulps without significantly affecting its brightness (Table III). The strength properties and brightnesses of the sweetgum pulps made by both the

Table V. One-Stage Bleaching of Mixed Southern Oak[a] Cold Caustic Soda Pulps with Calcium Hypochlorite

Pulp			Bleaching treatment[b]							
Caustic soda steep			Chemicals applied[c]					Properties of pulp sheets		
No.	Concentration, g.p.l.	Temperature, °C.	Bleach no.	Hypochlorite, %	Caustic soda, %	Sodium silicate, %	Duration, min.	pH	Brightness, %	Opacity,[d] %	Density, g./cc.
3382	0[e]	24	Unbleached	..	..	..	..	...	42.9	..	..
3382	0[e]	24	3878	6.0	3.0	4.0	25	11.2–10.8	60.5	..	..
3382	0[e]	24	3879	10.0	4.0	4.0	75	11.4– 9.1	69.2	79.0	0.25
3375	7.4	25	Unbleached	..	..	..	..	...	41.6	..	..
3375	7.4	25	3884	6.0	3.0	4.0	40	11.6–10.0	53.9	..	..
3375	7.4	25	3885	10.0	4.0	4.0	65	11.9– 9.8	67.7	..	..
3366	14.7	25	Unbleached	..	..	..	..	...	44.1	..	..
3366	14.7	25	3875	6.0	3.0	4.0	40	11.5–10.5	58.4	..	..
3366	14.7	25	3849	10.0	4.0	4.0	45	12.5– 8.7	71.9	81.7	0.33
3366	14.7	25	3850	15.0	4.0	4.0	55	11.5– 8.5	73.1	82.8	0.33
3363	35.1	25	Unbleached	..	..	..	..	...	42.3	..	..
3363	35.1	25	3872	3.0	2.0	4.0	15	11.4–11.2	47.5	..	..
3363	35.1	25	3873	6.0	3.0	4.0	40	11.5–10.8	56.9	..	..
3363	35.1	25	3851	10.0	4.0	4.0	45	12.2–10.4	66.4	81.3	0.38
3363	35.1	25	3852	15.0	4.0	4.0	50	11.9– 9.6	71.8	83.6	0.35
3369	77.8	26	Unbleached	..	..	..	..	...	39.4	..	..
3369	77.8	26	3874	6.0	3.0	4.0	45	11.7–10.9	56.9	..	..
3369	77.8	26	3853	10.0	4.0	4.0	100	12.1– 9.1	72.4	81.0	0.45
3369	77.8	26	3854	15.0	4.0	4.0	115	12.2– 9.4	73.1	80.8	0.44
3371	34.6	60	Unbleached	..	..	..	..	...	37.7	..	..
3371	34.6	60	3876	6.0	3.0	4.0	50	11.6–10.2	53.3	..	..
3371	34.6	60	3877	10.0	4.0	4.0	100	11.7–10.0	62.6	..	..
3383	35.5	89	Unbleached	..	..	..	..	...	33.8	..	..
3383	35.5	89	3880	6.0	3.0	4.0	40	11.5–10.9	51.3	..	..
3383	35.5	89	3881	10.0	4.0	4.0	100	11.7–10.0	61.6	77.0	0.35

[a] 80% of water oak and 20% of willow oak.
[b] Temperature, 37°C. and consistence, 10%.
[c] Based on pulp weight, moisture-free. The percentage of hypochlorite is in terms of available chlorine.
[d] Corrected for a weight of 37 lb. per ream of 500 sheets, 25 by 40 inches.
[e] Water steep.

continuous and batch methods were about the same as those of pulps made in the pilot-scale equipment from both the water and willow oak mixture and the southern hardwood mixture containing mostly oaks, gums, and poplar using similar chemical concentrations of between 50 and 60 g.p.l. (Table III). Cold soda pulp made from cottonwood was somewhat stronger, as shown in Table III, and had a comparatively high unbleached brightness of 51.9%.

Boardmaking

Cold soda pulps made continuously from (1) the mixture of 80% of water oak and 20% of willow oak, (2) cottonwood, and (3) the mixture of 1 part of red oak and 2 parts of white oak were converted into 26-lb. (per 1000 sq. ft.) corrugating boards on a 13-in. fourdrinier paper machine. Strength tests on the corrugating boards were made according to standard methods (Table IV). In addition, a Concora medium tester was used to determine the flat crush resistance of the boards in the corrugated conditions.

As shown in Table IV, the strength properties, including Concora, for the corrugating boards made from pulps produced from the two oak mixtures were very similar. Their Concora values (54.1 and 51.3 lb.) were somewhat below the commercial range of 70 to 80 lb., but in ring compression resistances they compared very closely wth commercial boards. The board made from the cottonwood cold soda pulp were somewhat stronger than the boards containing the oak mixture pulps, and it had a good Concora value of 77.4 lb. (Table IV).

Bleaching

Small-scale calcium hypochlorite bleaching trials were made on selected cold soda pulps prepared from the water oak-willow oak mixture to determine the effects of variations in caustic soda concentration and temperature durng pulping on the brightness and opacity of the bleached pulps. Dosages of chemicals and the bleaching conditions are given in Table V. Sodium silicate solution was added to the pulp to minimize strength loss. Caustic soda in amounts approximately proportional to the amounts of hypochlorite was added with the bleach liquor to provide the high alkalinity essential for effective bleaching with hypochlorites. The temperature and consistence, 37°C. and 10%, respectively, were in the range usually found in commercial hypochlorite bleaching. The bleached pulps were washed thoroughly before the test sheets were formed.

Bleaching results showed that the brightness of the oak bleached cold soda pulps was roughly proportional to the brightness of the unbleached pulps and that pulps made under favorable steeping conditions can be bleached to about 60 and 70% brightness with 6 and 10%, respectively, of available chlorine (moisture-free pulp basis). With these dosages, the gain in brightness per pound of hypochlorite applied was higher than with either higher or lower amounts of hypochlorite. As shown in Fig. 3, increasing the temperature of the caustic soda pulping treatment in a range of from 25 to 89°C. decreased the brightness of pulp bleached with 10% of available chlorine (moisture-free pulp basis) about 5 percentage points. There was no consistent relationship between the concentration of the pulping liquor and final brightness.

Table VI. Screen Classification and Opacity of Bleached Cold Soda Pulps Prepared from a Mixture Consisting 80% of Water Oak and 20% of Willow Oak

Bleach no.[a]	*Freeness (Canadian Standard), ml.*	*Pulp fraction* — *Retained on 28-mesh screen, %*	*Between 28- and 48-mesh screen, %*	*Between 48- and 100-mesh screen, %*	*Between 100- and 200-mesh screen, %*	*Passing through 200-mesh screen, %*	*Brightness (G.E. equivalent), %*	*Opacity, %*	*Density, g./cc.*
				Bleached Cold Soda[b]					
4268	130	4.2	17.9	26.0	16.3	35.6	65.5	82.5	0.45
4266	85	4.4	14.8	24.1	18.5	38.2	65.5	86.2	0.42
				Commercial Bleached Groundwood[c]					
..	70	3.1	15.7	21.5	14.4	43.3	69.0	92.7	0.49

[a] Bleached in a single-stage with 8.0% available chlorine in the form of calcium hypochlorite.
[b] Pulp prepared continuously in a roll mill using 8.1% of sodium hydroxide (moisture-free wood basis) and refined in two passes through a double-disk mil. Total energy consumed was 45.7 hp.-days per ton of air-dry pulp.
[c] Prepared from a 50-50 mixture of spruce and aspen.

Opacity values of test sheets made from the bleached pulps fell within a fairly narrow range and showed no consistent relationship to pulp yield, pulping liquor concentration, or bleached pulp brightness. As found previously (*4*), it is likely that the opacity of these pulps was influenced chiefly by such factors as the amount of fine material and the degree of bonding between fibers. The strong influence of the amount of fine material on opacity is shown in Table VI. Results of screen classification tests made in a Bauer-McNett Classifier on pulps bleached in pilot-scale equipment showed that, when the amount of fine material in the pulp was decreased from 38.2 to 35.6%, probably because of losses during washing, its opacity dropped from 86.2 to 82.5%. A conventional groundwood pulp included for comparison purposes contained 43.3% of fines and had an opacity of 92.7% (Table VI). This suggests the possibility of increasing the opacity of cold soda pulp to the same level as that of conventional groundwood by increasing its content of fines to 43%.

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Factors Influencing the Performance of Melamine Laminating Resins

H. P. LEDDEN and I. H. UPDEGRAFF

The construction of a standard decorative laminate containing melamine resin is given. The resin is described in terms of the approximate degree of polymerization, and this factor is correlated with the dilutability or water tolerance of the resin. Residual moisture in the resin-treated paper is discussed in terms of its influence on flow and on the dimensional stability of the laminate. Additives or modifiers are discussed with reference to their effect on flow, shrinkage, and hardness at elevated temperatures.

THE well-known standard decorative laminate of today is the product of several centuries of gradual development. The basic art is a very ancient one, with roots in the papier mâché trade. As early as 1772, an English patent described a board made from sheets of paper which had been soaked in glue, laminated, dried, then saturated with a vegetable drying oil and finally cured to produce a strong, water-resistant panel recommended for coach building, doors, furniture, and the like.

Synthetic resins began to replace the natural glues and oils at the beginning of the present century. Phenolics were, and still are, satisfactory in dark-colored laminates, but the appearance of urea resins on the scene in the 1920's opened up a vast light-colored field. Melamine resins were introduced commercially in 1938-39. Besides light color, these resins had such outstanding characteristics of hardness and stain resistance that they quickly dominated the field. Since then, melamine has been modified in various ways to effect further improvements. The development process which started so long ago is still going on.

DECORATIVE LAMINATE ASSEMBLY

The composition of a standard decorative laminate may vary somewhat among the many individual laminators, but the assembly illustrated in Table I may be considered to be representative. Melamine resins are generally used in the overlay and print sheets, and phenolic resin in the kraft core. The assembly is pressed at about 300°F., at a pressure of at least 1000 p.s.i. for about 15 min. In commercial practice, the entire cycle is much longer, since it involve heating and subsequently cooling a multiple-opening laminating press. Nevertheless the actual time of each laminate at maximum curing temperature is in the 15-min. range.

The finished laminate must meet certain quality requirements, and these depend broadly on the paper, the processing and the resin. A few of the numerous variables in the over-all operation may be listed as follows: (1) type of resin*; (2) resin content*; (3) residual volatile content*; (4) flow properties of resin*; (5) type of filler*; (6) arrangement of plies; (7) cure conditions: (a) pressure, (b) temperature, (c) time, and (d) rate of heating and cooling

Table I. Decorative Laminate Assembly

		Function	*Thickness, mils/ply*	*Resin content, %*
	Overlay	Protection	3–4	65–70
	Print	Design	8–10	40–50
	Core sheets	Strength and rigidity	10–12	30–40
	Backing	Balance	...	...
Total thickness of cured laminate:			50–60 mils	

The purpose of this article is to deal with the problem from the standpoint of the resins themselves.

MELAMINE-FORMALDEHYDE REACTION

A typical melamine laminating resin is prepared by reacting melamine with formaldehyde in the molar ratio of 1 to 2 until a predetermined end point is reached. In the first step, or A stage, a monomeric methylol melamine is formed which is quite soluble in

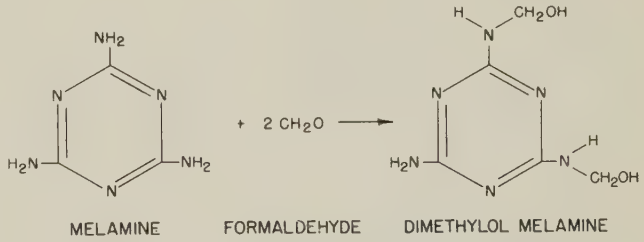

Fig. 1. Formation of dimethylol melamine

water (Fig. 1). In the B stage, some methylol melamine reacts with itself to form a low-molecular-weight polymer that is comparatively insoluble in water but compatible with the water-soluble monomeric methylol melamine. The simplest example is the dimer, comprising two triazine molecules joined by a methylene bridge (Fig. 2). In the C stage, or cured state, cross-linking occurs and a hard, insoluble, infusible resin is formed. This is illustrated in Fig. 3, in which each hexagon represents a melamine nucleus; the connecting lines are methylene bridges, and the unconnected lines are methylol groups (*1*).

H. P. LEDDEN, Research Chemist, and I. H. UPDEGRAFF, Group Leader, Research Div., Stamford Laboratories, American Cyanamid Co., Stamford, Conn.

* The first five variables must be considered for each individual lamina at time of curing.

In practice, the resin is reacted to a dilutability of between 20 to 30%, i.e., an aqueous solution of the resin can be diluted with water until the solids, expressed as a percentage of the total solution, is 20 to 30 before clouding or precipitation occurs. This test is conducted

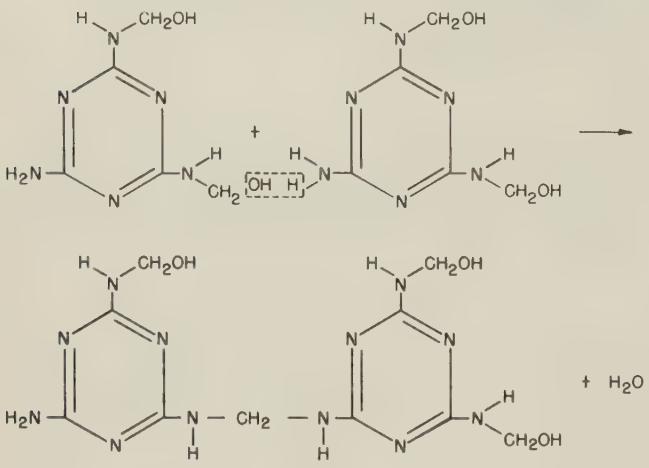

Fig. 2. Formation of dimer

at 25°C. If the resin is not reacted far enough, it may be unstable; if it is reacted too far, it may not be sufficiently dilutable to produce a treating solution that will give the desired resin content in the paper. Commercial resins may be spray-dried to produce a stable powder which may be redissolved by the laminator prior to use.

Recent laboratory work has been directed toward exploring the relationship between the dilutability and the actual degree of polymerization of the resin. The question to be answered was this: at a given dilutability, how much melamine is in the form of soluble monomer and how much has been converted to the less soluble polymer?

This was done according to the method of Okano and Ogata (*2*) by reacting the resin with an alkaline solution of iodine. A similar technique has also been used by de Jong and de Jonge in a study of urea-formaldehyde resins (*3*). Under the conditions of the

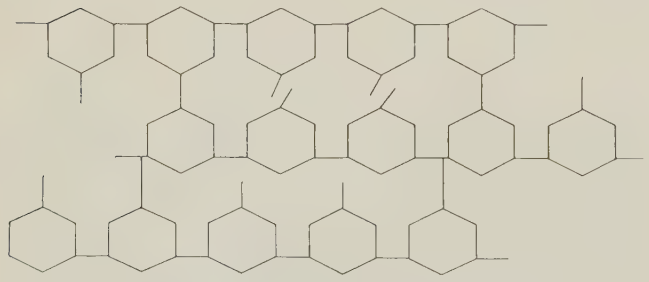

Fig. 3. Diagrammatic illustration of cured resin

test, the methylol groups are labile and in equilibrium with free formaldehyde. This is readily oxidized by the hypoidite which is present in the solution. The methylene linkages, on the other hand, remain unaffected. The methylol content can, therefore, be estimated by the amount of iodine used up. Typical results of this work are shown in Fig. 4. It may be seen that about 90% of the formaldehyde used in the resin can be accounted for as methylol groups and free formaldehyde when a 2 to 1 formaldehyde-melamine resin has been reacted to a dilutability of 22%. This leaves only 10% of the formaldehyde combined in the form of methylene linkages. Uncombined formaldehyde was assumed to be negligible in the spray-dried melamine resin used in these tests. Assuming that the polymer fraction is predominantly in the dimer stage, then about 40% by weight of the resin exists in this form while 60% remains as monomeric methylol melamines. The degree of polymerization of this resin is evidently quite low. Some further resinification takes place when the treated paper is dried, but this was not studied.

Analyses of resins prepared under different conditions of temperature and pH indicated that the relationship between dilutability and amount of polymerization was

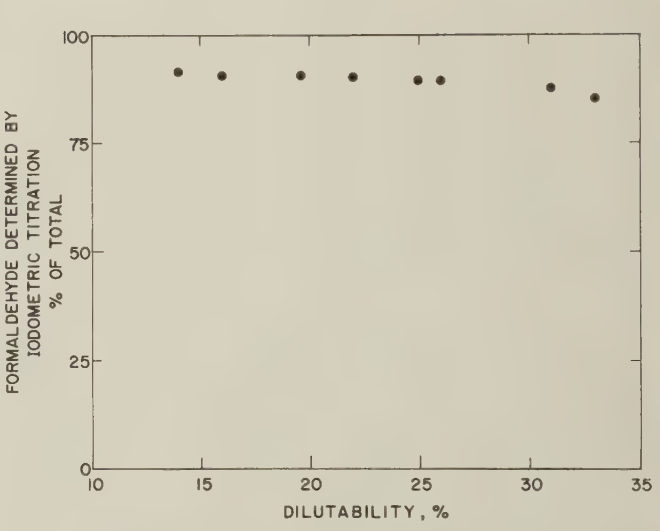

Fig. 4. Dilutability versus amount of formaldehyde combined in the form of methylol groups

valid over the range of conditions likely to be encountered in preparing these resins.

VOLATILE AND MODIFIER VERSUS FLOW

The degree of polymerization is only one of the factors influencing the flow of the resin. It is generally agreed that there must be sufficient flow of resin among the paper fibers during pressing in order to achieve optimum appearance, water resistance, and strength in the finished laminate. The flow of melamine resin is promoted to a great extent by the volatile, or free moisture, remaining in the treated paper before pressing. Some test results with alpha-cellulose overlay paper are shown in Fig. 5.

The free moisture is augmented by the water of condensation, i.e., the water which splits out during polymerization. The water from these two sources results in a less dimensionally stable laminate, as evidenced by a tendency to warp, or, if the warping is not relieved, to craze on the surface. The problem, then, becomes one of selecting a flow-promoter other than water.

Figure 6 illustrates the difference in flow between an unmodified melamine laminating resin and one that is chemically modified. These resins are available commercially as CYMEL 405 resin (*4*) and CYMEL 430 resin (*4*), respectively. These data were obtained

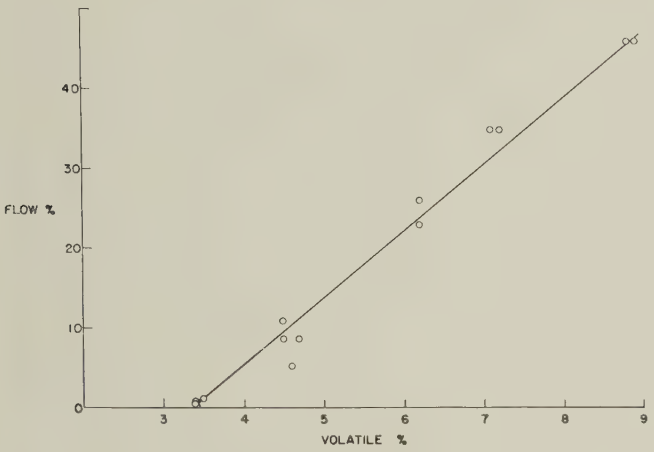

Fig. 5. Volatile versus flow of unmodified melamine resin-treated alpha cellulose type overlay paper

Volatile = per cent weight loss of 4 in. disk, 5 min. at 160°C. Flow = per cent weight loss of 8 stacked $1^{3}/_{4}$-in. disks, pressed 3 min. at 1100 p.s.i., 150°C.

with rayon-type overlay paper and show the effect over a fairly wide range of volatiles. The flow may be influenced by other factors such as the pH of both resin and paper, the degree of saturation of the sheet, and the type of solvent used in the treating bath. Keeping these variables constant, however, it becomes apparent at once that an effective modifier results in improved flow. This flow, moreover, can be utilized to produce a significant improvement in dimensional stability. The effect, it must be emphasized, is in-

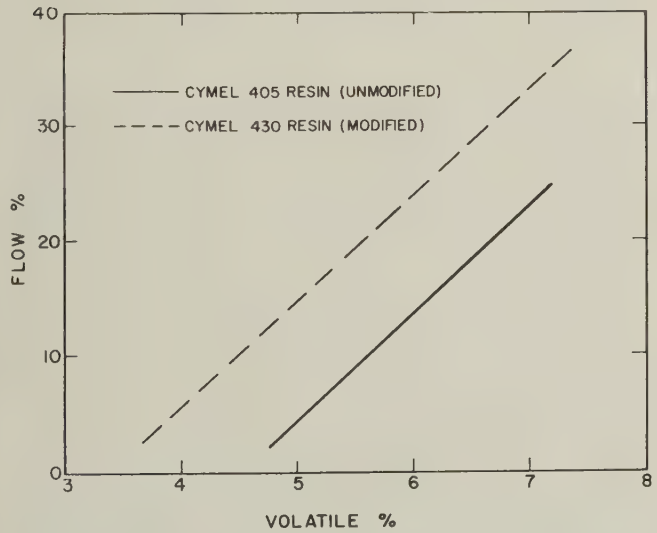

Fig. 6. Effect of modifier on flow of melamine resin-treated rayon-type overlay paper

direct, and occurs only if the laminate is pressed at the lower volatile made possible by the presence of the modifier.

Figure 7 illustrates this principle. Dimensional stability is here indicated by the shrinkage in mils per inch of a 4 by 4 by $^{1}/_{8}$ in. laminate (made from 36 plies of overlay) after exposure to a temperature of 104°C. for 48 hr. Rayon type overlay paper was used, treated to a 67 to 69% resin content with melamine resin containing a commercial modifier, Plasticizer 120.

POSTFORMING

The flow of the resin during cure is not the only type of softening that the laminator may deal with. If the cured laminate is to be postformed, it must be heated briefly and then bent quickly to a desired curve. Many factors enter into the success of this operation,

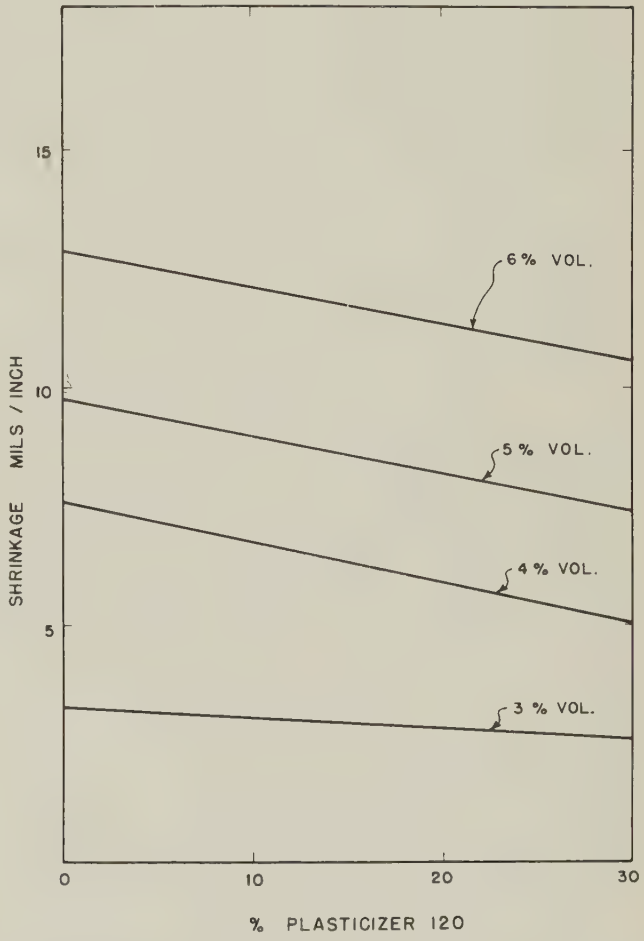

Fig. 7. Effect of modifier on dimensional stability of melamine resin laminates

in particular, the type and arrangement of the paper plies in the core. The behavior of the melamine resin component may be studied by preparing solid laminates from melamine-treated paper alone, and measuring the property called "hot hardness."

This ability of a panel to soften under heat may be determined in two ways. One method requires that the laminate be heated in an oven for 20 min. at 135°C. Immediately upon removal from the oven, Rockwell hardness is determined at 50-sec. intervals as the sample cools (Fig. 8).

Since the resin may continue to react while the panel is heated for postforming, a more realistic and appro-

priate method is to measure the changing hardness as the temperature of the laminate rises. This is called "Ito hardness," after the Japanese inventor of the technique (Fig. 9, (*5*)).

Actual postforming tests confirm the results of the hot hardness determinations. As expected, panels containing modified melamine resin could be postformed at a lower temperature and/or to a smaller radius than similar laminates made with an unmodified resin. The modifier clearly influences the behavior of the laminate at elevated temperatures but this effect is not observed at room temperature. The laminate continues to meet the generally accepted NEMA requirements for stain and water resistance and even resistance to high temperature and boiling water.

A successful modifier further provides an indirect benefit by permitting the use of a lower resin content in the print sheet. The increased flow results in a more efficient control of show-through of phenolic resin from the core of the laminate.

An important point to remember about modified melamine resins is that they must generally be handled in a specific way. The superior qualities claimed for them can be realized only when these resins are used under conditions that are recommended for taking advantage of their special characteristics.

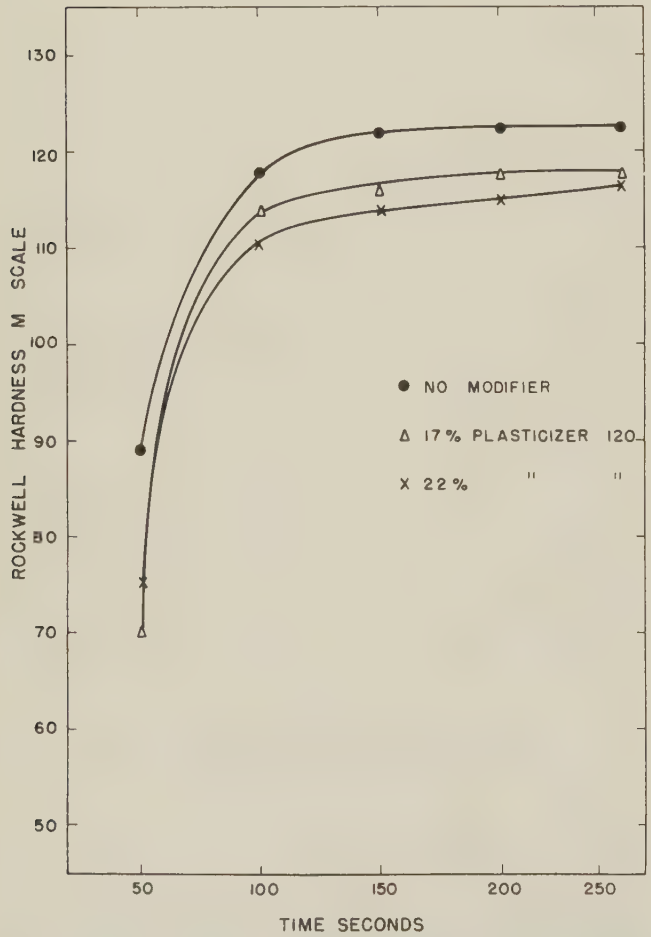

Fig. 8. Hardness of melamine laminates during cooling after heating 20 min. at 135°C.; percentages indicate amounts of Plasticizer 120

APPENDIX

Determination of Methylol Content

Weigh 1 to 2 drops of resin solution to the nearest 0.0001 g. in a 125-ml. Erlenmeyer flask. Add approximately 5 ml. of 4 *N* NaOH. Then, add exactly 50 ml. of 0.05 *N* I_2 solution and allow to stand at room temperature (23°C.) in a dark place for 1 hr. Determine the amount of iodine remaining by adding approximately 13 ml. of 2 *N* H_2SO_4 and titrating the liberated iodine immediately with 0.1 *N* sodium thiosulphate solution. A few drops of starch solution should be added near the end of the titration to facilitate reading the end point. A blank containing no resin must be run at the same time.

Weight of formaldehyde = net ml. thiosulphate × 0.0015

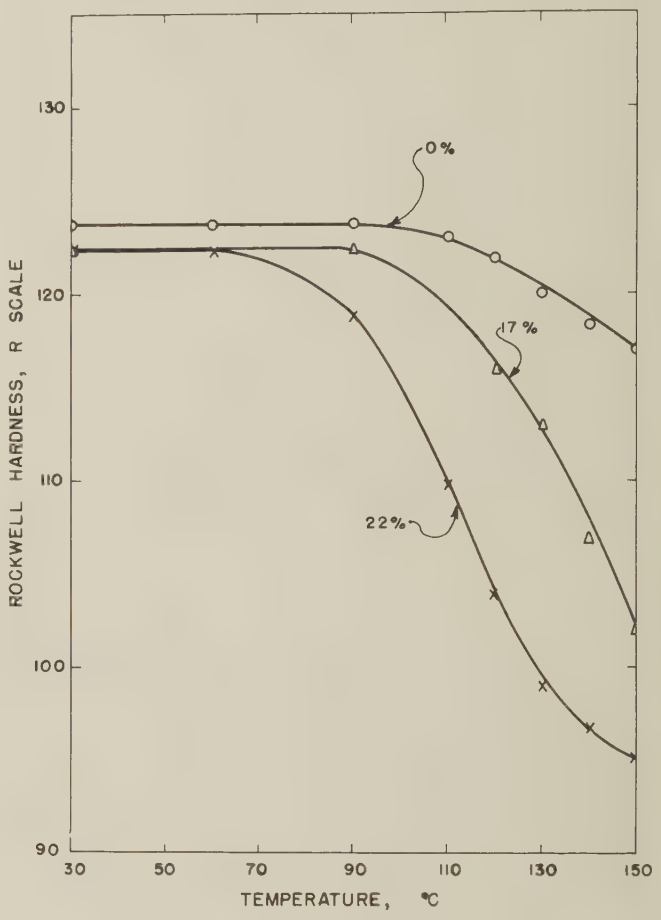

Fig. 9. ITO hardness of melamine resin laminates during heating at rate of 2°C. per min.

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2. Okano, M., and Ogata, Y., *J.A.C.S.* 74: 5728 (1952).
3. de Jong, J. I., and de Jonge, J., *Recueil* 71: 643 (1952).
4. CYMEL is the registered trademark of American Cyanamid Co.
5. Ito, K., *J. Scientific Research Institute of Japan* 48: 154 (1954).

Presented at the Twelfth Plastics-Paper Conference of the Technical Association of the Pulp and Paper Industry, Cincinnati, Ohio, Oct. 7–9, 1957.

The authors wish to express their appreciation to Alex Coutras and Genevieve T. Parker who also contributed to this project.

ASSOCIATION NEWS AND EVENTS

National Conferences

Tenth Coating Conference, Statler Hotel, Boston, Mass., May 25–27, 1959.

Tenth Testing Conference, Multnomah Hotel, Portland, Ore., Aug. 17–21, 1959.

Fundamental Research-Wet Strength Conference, I.P.C., Appleton, Wis., Sept. 9–11, 1959.

Ninth Corrugated Containers Conference, Jung Hotel, New Orleans, La., Sept. 15–17, 1959.

Fourteenth Paper-Plastics Conference, Edgewater Beach Hotel, Chicago, Ill., Sept. 21–23, 1959.

Fourteenth Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., Oct. 12–15, 1959.

Thirteenth Alkaline Pulping Conference, Robert Meyer Hotel, Jacksonville, Fla., Nov. 4–6, 1959.

Local Section Meetings

Pacific: Camas, Wash., April 7, 1959, "Shibley Award Meeting"; Gearhart, Ore., May 21–23, 1959, "Multiple Water Use." Joint TAPPI-Superintendents annual meeting.

Golden Gate District (Pacific Section): Jan. 27, 1959; March 24, 1959; May 5, 1959.

Kalamazoo Valley: Inman's Restaurant, Galesburg, Mich., March 19, 1959, "Printability of Paper and Paperboard"; Inman's Restaurant, Galesburg, Mich., April 23, 1959; Hotel Harris, Kalamazoo, Mich., May 14, 1959, Recognition Night for Western Michigan University award winners.

Chicago (Chicago Bar Association, 29 So. LaSalle St., Chicago, Ill.): March 3, 1959; April 7, 1959; May 5, 1959.

St. Louis District (Chicago Section) Le Chateau Restaurant, 10405 Clayton Road, St. Louis (all meetings): "Nondestructive Testing of Paper," by Arthur C. Dreschfield, Chicago Testing Laboratories, Chicago, Ill., April 16, 1959.

Maine-New Hampshire: Samoset Hotel, Rockland, Me., June 12–13, 1959.

New England: Roger Smith Hotel, Holyoke, Mass., April 10, 1959; June, 1959. Place and date to be determined.

Eastern District (New England Section): Greater Boston Area, March 9, 1959; June 1959, annual meeting with New England Section.

Southeastern: Francis Marion Hotel, Charleston, S. C., March 20, 1959; Jekyll Island Hotel, Jekyll Island, Ga. May 8, 1959.

Gulf Coast District (Southeastern Section): Mobile, Ala., March 13, 1959; New Orleans, La., May 15, 1959.

Virginia-Carolina: Thomas Jefferson Hotel, Richmond, Va. March 20, 1959; Franklin, Va., May 15, 1959. Visit to mill of Union Bag-Camp Paper Corp.

Lake Erie: Carter Hotel, Feb. 20, 1959, "Advantages and Disadvantages of Each Type of Printing Process"; Carter Hotel, April 17, 1959, "Characteristics of Clupak Paper, What Is It? What Is Its Future?"

Papermakers and Associates of Southern California: Los Angeles, Calif., March 19, 1959; May 21, 1959.

Lake States: Kaukauna, Wis., March 10, 1959, "Water Removal on Paper Machines"; Appleton, Wis., April 14, 1959, "Engineering"; Menasha, Wis., May 12, 1959, C. J. West Award Meeting.

Delaware Valley (all meetings held at Engineers Club, Philadelphia, Pa.): March 26, 1959; April 23, 1959; May 22, 1959.

Ohio: Chillicothe Elks Club, Chillicothe, Ohio, March 12, 1959; visit to mill of Chillicothe Paper Co. to see new paper machine; American Legion Hall, Middletown, Ohio, April 14, 1959; Hartwell Reaction Center, Cincinnati, Ohio, May 14, 1959, Annual Meeting.

Indiana District (Ohio Section) (meetings at the Hunt Room, Marott Hotel, Indianapolis, Ind.): March 17, 1959; April 23, 1959; May 19, 1959; and June 16, 1959.

Empire State: Whiteface Inn, Whiteface, N. Y., June 11–14, 1959. Annual meeting.

Empire State (Central District) (all meetings to be held at the University Club, 431 East Fayette St., Syracuse, N. Y.): March 6, 1959; April 3, 1959, visit to mill of Armstrong Cork Co., Fulton, N. Y. Dinner meeting at Fulton Chamber of Commerce; May 1, 1959, "Senior Night," NYSCF; May 21, 1959, annual meeting of Fulton C. of C., Fulton, N.Y.

Empire State (Metropolitan District) (all meetings to be held at 465 Lexington Ave., New York, N. Y.): March 10, 1959, "Coating Methods"; April 14, 1959, "Development in the Printing Industry"; May 12, 1959; Annual Meeting.

Empire State (Northern District) (all meetings to be held at Woodruff Hotel, Watertown, N. Y.): "Corrosion Measurements," March 12, 1959; Northern District Awards Program, April 9, 1959; Annual Meeting May 14, 1959.

Empire State (Eastern District) (all meetings to be held at Queensbury Hotel, Glens Falls, N. Y.): Junior Awards Night, March 19, 1959; Ladies' Night, April 18, 1959; Annual Symposium, subject to be announced, May 21, 1959.

Empire State (Western District) (all meetings at the Prospect House, Niagara Falls, N. Y., unless otherwise indicated): Joint Meeting with Niagara Branch of C.P.P.A. Technical Section, March 11, 1959; Annual Ladies' Night—April; Field Trip—May (Details to be announced later).

Other 1959 Conferences

June 17–20	CPPA Summer Meeting, Manor Richelieu Hotel, Murray Bay, P. Q.
Sept. 13–18	Am. Chem. Society, Atlantic City, N. J.
Oct. 11–16	ASTM, San Francisco, Calif.
Oct. 26–28	Packaging Institute, Statler Hotel, New York, N. Y.
Nov. 9–11	National Paperboard Assoc., New York, N. Y.

Fourteenth Engineering Conference

M. H. Fisher of Westinghouse Electric Corp. has been named chairman of the local arrangements committee for the 14th Engineering Conference of the Technical Association of the Pulp and Paper Industry which is to be held at the Penn-Sheraton Hotel in Pittsburgh, Pa., on Oct. 12–15, 1959.

It marks the first time that the conference has been scheduled for Pittsburgh according to the arrangements committee chairman.

The committee in charge of arrangements for the conference has been named as follows: V. P. Owens, Combustion Engineering Co., Inc., Engineering Division secretary and program chairman; E. V. Alderson, Heppenstal Co., secretary; E. W. Hopper, consulting engineer, treasurer; H. O. Teeple, TAPPI Engineering Division associate; A. M. Brooks, Columbia-Southern Chemical Corp., J. W. Morgan,

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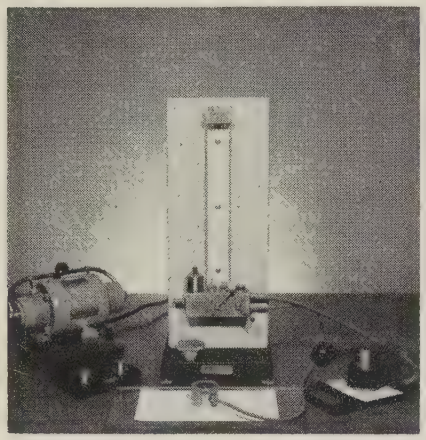

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Also, L. B. Taylor, Columbia-Southern Chemical Corp., publicity: C. D. Haxby, Rust Engineering Co., and R. R. Digby, Eichleay Corp., hospitality; G. W. Newland, Walworth Co., and H. W. Fritts, Aluminum Co. of America, printing; D. T. Smith, Jessop Steel Co. and W. G. Gerstacker, National Annealing Box Co., mill tours.

Serving on the Local Arrangements Committee which is already formulating plans for the 14th Engineering Conference of the Technical Association of the Pulp and Paper Industry to be held in Pittsburgh, Pa., on October 12–15 are shown above (seated l. to r.): C. V. Spangler, J. F. Pritchard & Co. Engineers; A. M. Brooks, Columbia-Southern Chemical Corp.; A. O. Caldwell, Service & Erection Co.; V. P. Owens, Combustion Engineering Co., Inc.; M. H. Fisher, Westinghouse Electric Corp.; E. V. Alderson, Heppenstal Co., J. W. Morgan, Celli-Flynn Co.; L. B. Taylor, Columbia Southern Chemical Corp.; and H. A. Latta, Reliance Electric & Engineering Co. (Standing l. to r.): C. D. Haxby, Rust Engineering Co.; G. W. Newland, Walworth Co.; W. R. McNally, Link-Belt Co.; E. W. Hopper, consulting engineer; R. R. Digby, Eichleay Corp.; H. W. Fritts, Aluminum Co. of America; R. E. Nelson, Nelson Engineering Sales Co.; D. T. Smith, Jessop Steel Co.; H. O. Teeple, TAPPI; and W. G. Gerstacker, National Annealing Box Co.

Mr. Fisher reported following the January 19th meeting of the local arrangements committee that plans are shaping up rapidly for the conference next fall. Various committee chairman revealed that arrangements are being completed for presentation of technical papers and discussion sessions, luncheons, an official dinner, and several plant visitations in the vicinity of Pittsburgh.

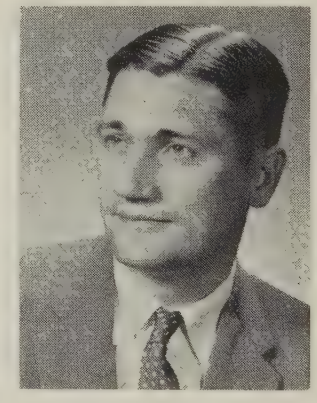
Mr. Fisher also announced that the next meeting of the local arrangements committee has been scheduled for March 30 with others to follow prior to the October conference.

German Association Annual Meeting

The Verein der Zellstoff-und Papier-Chemiker und-Ingenieure will hold its annual meeting in Baden-Baden from June 23–26, 1959. Complete program will appear in the May issue of "Das Papier."

Testing Division

C. E. Brandon, director of Pulp and Paper Technology, Miami University, Oxford, Ohio, has been appointed general chairman of the TAPPI Testing Division, succeeding P. W. Bartholomew, Minnesota and Ontario Paper Co., International Falls, Minn. who retired following the 9th TAPPI Testing Conference last September.



C. E. Brandon

Mr. Brandon has been a vice-chairman of the Testing Division for 4 years, and has been active in various testing division committees for many years. He is a past chairman of the Microscopy Committee, was founding chairman of the Precision Committee, and has been a member of the Pulp Testing Committee for 15 years. He acted as general chairman of the 6th TAPPI Testing Conference, held in Dayton, Ohio, and has published papers on precision, microscopical identification of pigments, and viscosity testing. Mr. Brandon was formerly technical director of Howard Paper Mills, Dayton, Ohio.

ASME (Lubrication Division)

The annual Spring Conference of the ASME Lubrication Division will be held this year on March 16 and 17 at the Franklin Institute in Philadelphia. The general subject of the conference is "Wear of Lubricated Surfaces." Three of the sessions of the conference will be conducted as a symposium and formal papers will be presented at one session.

Session I—Symposium. Influence of Lubricants and Additives on Wear Reduction
Session II. Formal papers
Session III—Symposium. Wear Control through Design
Session IV—Symposium. Radioactive and Other Studies in Wear Research

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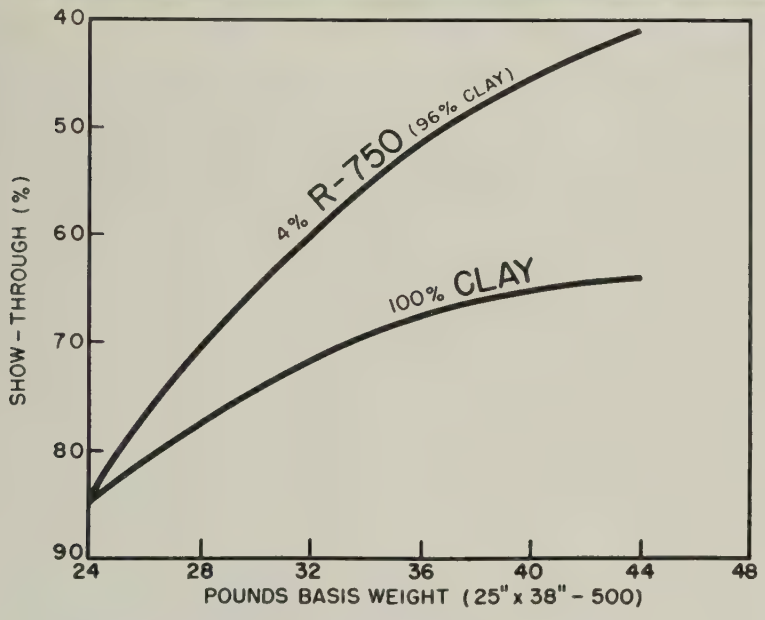

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Alvin Aronson, Manager, New York Office, Thomson-National Press Co., Franklin, Mass.

Raman Lal Baheti, Senior Assistant, Pilot Plant Research, The Gwalior Rayon Silk Mfg. Co. Ltd., Birlagram, Nagda, India, a 1953 graduate of Laxminanaya Institute of Technology.

Alfred J. Barchi, Director of Engineering, Barrett Div., Allied Chemical Corp., New York, N. Y., a 1943 graduate of Stevens Institute of Technology.

Dwight M. Beaty, Jr., Senior Chemist, Pulp Mill, Champion Paper & Fibre Co., Canton, N. C., a 1950 graduate of North Carolina State College.

Ronald L. Benson, Student, New York State College of Forestry, Syracuse, N. Y.

Dean K. Bredeson, Sales Engineer, French Oil Mill Machinery Co., Piqua, Ohio, a 1942 graduate of Winona State College.

Adam Bridge, Sales Engineer, Black-Clawson Co., Shartle Div., Middletown, Ohio.

Richard J. Burns, Director and Technical Manager, Walmsleys (Bury) Ltd., Atlas Works, Bury, Lancs., England.

Jan E. Callenfels, Director, Potato Starch Factory, N. V. Onderons, De Krim (O), The Netherlands, a 1930 graduate of the College of Agriculture.

Luigi Carcano, Technical Director, C. Carcano & Fllofu C. S.p.A., Maslianico (Como), Italy, a 1946 graduate of the University di Pavia, with a Ph.D. degree.

Henry C. Carlson, Product Manager, Chemicals and Coatings, Koppers Co., Inc., Pittsburgh, Pa., a 1937 graduate of the University of Minnesota.

Vicente Carreto, General Manager, Equipos de Proceso, S.A., Mexico, D.F., a 1950 graduate of Louisiana State University.

David J. Chen, Graduate Student, College of Forestry, State University of New York.

Moss B. Christian, Research Director, Chicago Mill & Lumber Co., Tallulah, La., a 1938 graduate of Louisiana State University.

Francis J. Clark, Managing Director, Reed Corrugated Cases Ltd., Brentford, Mddlx., England, a 1932 graduate of Manchester University.

Leonard J. Clifford, Night Shift Foreman, Spaulding Fibre Co., Tonawanda, N. Y.

C. Kenneth Cloninger, Sales Manager, Northern Region, Buckman Laboratories, Inc., Memphis, Tenn., a 1950 graduate of the University of Missouri with a Ph.D. degree.

Albert P. Collett, Manager, Groundwood Pulp Mill, Salsbrukets Tresliperi, Namdalen, Norway, a 1946 graduate of Oslo Technical University.

Cornelius A. Cunningham, Jr., Student, Lowell Technological Institute, Lowell, Mass.

Nicholas D. De Candia, Student, New York State College of Forestry, Syracuse, N. Y.

William J. Delaney, Microbiologist, Metalsalts Corp., Hawthorne, N. J., a 1952 graduate of Iona College.

Arthur Der Boghosian, Assistant to Chief Chemist, Tileston & Hollingsworth Co., Hyde Park, Mass., a 1954 graduate of Northeastern University.

Julian A. Dixon, Assistant Director, Technical Services, Riordon Sales Corp., New York, N.Y., a 1948 graduate of McGill University.

Harold E. Dunlap, Chief Draftsman, Lodding Engineering Corp., Auburn, Mass. Attended Worcester Junior College.

Albert Dupond, Chemist-Engineer, Compagnie Francaise des Matieres Colorantes, Les Roches de Condrieu, France.

Henry A. Dupuis, Assistant to Paper Mill Superintendent, Falulah Paper Co., Fitchburg, Mass.

Edward F. Elton, Student, Institute of Paper Chemistry, Appleton, Wis., a 1957 graduate of Stevens Institute of Technology.

Ichiro Endo, Chief, Research Dept., Mitsubishi Paper Mills Ltd., Tokyo, Japan, a 1938 graduate of Tokyo University.

Robert H. Flynn, Sales Engineer, B-I-F- Industries, Inc., Providence, R. I., a 1950 graduate of Providence College.

Leigh M. Freeman, District Sales Manager, Miller Freeman Publications, New York, N. Y., a 1952 graduate of Stanford University.

Herbert E. Freier, Leader, Technical Information Section, Minnesota Mining & Manufacturing Co., St. Paul, Minn., a 1946 graduate of the University of Illinois with a Ph.D. degree.

Fletcher A. Futch, Production Superintendent, Venezolana de Pulpa y Papel "Venepal," Carabobo, Venezuela, S. A.

Sudhir Kumar Ganguly, Manager, Pulp Mill, Shree Gopal Paper Mills Ltd., Ambala, Punjab, India, a 1945 graduate of Calcutta University.

Edward H. Hall, President and Treasurer, Morey Paper Mill Supply Co. and Fitchburg Screen Plate Co., Inc., Fitchburg, Mass.

Edward H. Hall, Jr., Salesman, Morey Paper Mill Supply Co., Fitchburg, Mass., a 1957 graduate of Harvard University.

G. Bancroft Hall, Salesman, Morey Paper Mill Supply Co., Fitchburg, Mass.

Mason Hayek, Research Supervisor, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1941 graduate of the University of Minnesota, with a Ph.D. degree from Indiana University in 1947.

C. Richard Heil, Chemist, Sorg Paper Co., Middletown, Ohio, a 1952 graduate of Ohio State University.

Dan E. Hendricks, Mill Manager, Hopper Paper Co., Reading, Pa., a 1942 graduate of James Milliken University.

Alfred K. Hobbs, Product Development Engineer, Crocker, Burbank & Co., Fitchburg, Mass., a 1950 graduate of the University of Maine.

Dale L. Huggins, Electrical Engineer, Bowaters Southern Paper Corp., Calhoun, Tenn., a 1950 graduate of Georgia Institute of Technology.

Farid S. Ibrahim, Technical Superintendent, Olinkraft, S. A., Santa Catarina, Brazil, a 1954 graduate of the Institute of Chemistry of Parana.

Ichiro Imai, Chief, Research Laboratory, Nihon Yushi Co. Ltd., Hyogo-ken, Japan, a 1937 graduate of Kyoto University.

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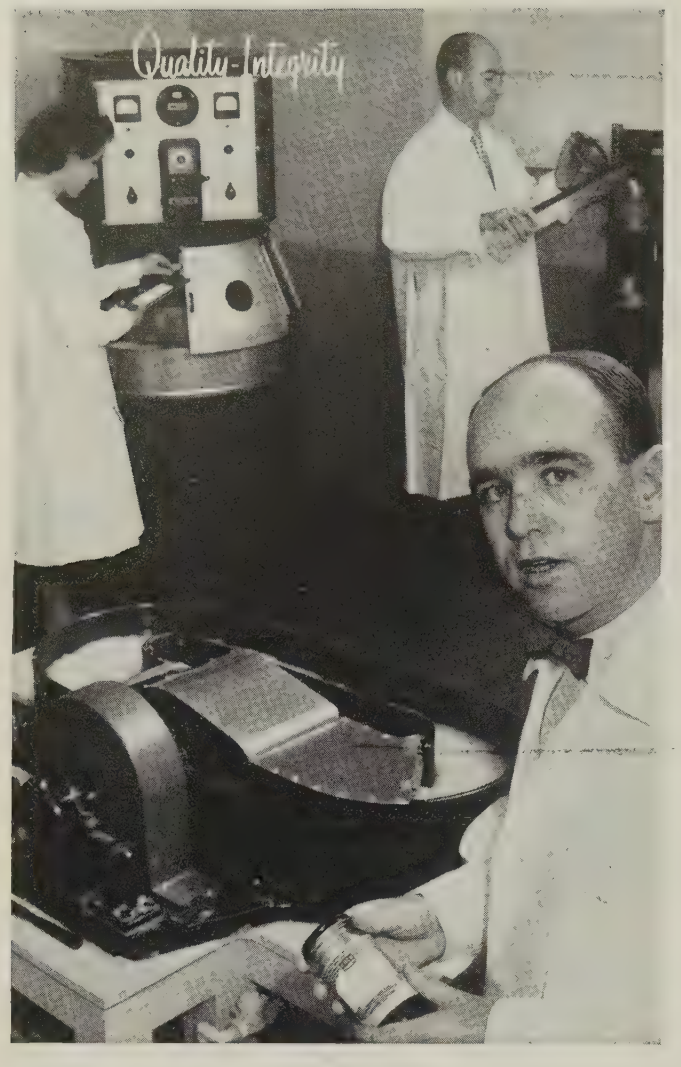

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Erik T. Jonsson, Technical Librarian, Stockholms Superfosfat Fabriks A/B, Ljungaverk, Sweden, a 1946 graduate of NKI Technical Institute.

Eric Kay, Director, Hall & Kay Ltd., Ashton-under-Lyne, Lancs., England, a 1933 graduate of Manchester College of Technology.

Gerhardt P. Kraske, Student, University of Maine, Orono, Me.

Joseph J. Latimer, Chemist, Air Reduction Co., Inc., Murray Hill, N. J., a 1955 graduate of Rutgers University.

Paul L. Leathers, Chemical Engineer, Hercules Powder Co., Savannah, Ga., a 1955 graduate of the University of Maine.

Rolv. Lindseth, Technical Director, Hunsfos Fabrikker, Vikeland, Nr. Kristiansand, Norway, a graduate of the Norwegian Technical University.

Marlin A. Lovensheimer, Paper Analyst, Mead Corp., Chillicothe, Ohio, a 1956 graduate of Ohio University.

John A. Maphis, Technical Superintendent, Container Corp. of America, Wabash, Ind., a 1952 graduate of Manchester College.

Frederick C. Masal, Chief Packaging and Service Engineer, Owens-Illinois, Toledo, Ohio, a 1931 graduate of Central Missouri State College.

Hugh M. McFarlane, Supervisor, Wastes and By-Products Section, Central Research & Development Div., Abitibi Power & Paper Co. Ltd., Sault Ste. Marie, Ont., Canada, a 1942 graduate of the University of Manitobe, with a Ph.D. degree from McGill University in 1950.

Ishwarlal B. Mody, Senior Assistant, Pulp Pilot Plant, Gwalior Rayon Silk Mfg. Co. Ltd., Birlagram, Nagda, India, a 1947 graduate of Bombay University.

Wilhelm Muller-Rid, Chief Engineer, J. M. Voith G.m.b.H., Heidenheim/Brenz, West Germany, a 1951 graduate of the Technical University, Darmstadt.

William G. F. Mundie, Salesman, Morey Paper Mill Supply Co., Fitchburg, Mass.

Robert L. Newton, Chief Corrugated Engineer, Owens-Illinois Technical Center, Toledo, Ohio, a 1940 graduate of Ohio State University.

Mme. Collette Noel, Librarian, Ecole Francaise de Papeterie, Grenoble (Isere), France, a 1952 graduate of Grenoble University.

Earl S. Packard, Head, Technical Service Div., Eastern Division of Standard Packaging Corp., Lincoln, Me., a 1950 graduate of the University of Maine.

Emilio Palazzi, Consulting Engineer, Milano, Italy.

Too Man Park, Foreman, Ground Wood Mill, The Korea Paper Mfg. Co., Kunsan City, Korea, a 1949 graduate of Yon Hi College.

Basil M. Parsons, Vice-President and Sales Manager, Thomson-National Press Co., Franklin, Mass.

Dante Pedrina, Technical Sales and Service, Fabriche Riunite Amido Glucosio Destrine, Milano, Italy, a 1950 graduate of the University of Ferrara with a Ph.D. degree.

Glen L. Phillips, Superintendent, Foil Div., Aluminum Co. of America, Davenport, Ia., a 1941 graduate of Purdue University.

F. Bruce Pickett, Chief, Standards and Specifications, Kimberly-Clark Corp., Neenah, Wis., a 1939 graduate of the University of Toronto.

Carl V. Piper, Manager, Analytical Dept., The Institute of Paper Chemistry, Appleton, Wis., a 1930 graduate of the University of Wisconsin.

Fred L. Platt, Resident Mill Manager, Spruce Falls Power

& Paper Co. Ltd., Kapuskasing, Ont., Canada, a 1931 graduate of the University of Toronto.

Charles J. Priest, Chief Chemist, C.A. Venezolana de Pulpa y Papel "Venepal," Carabobo, Venezuela, S.A., a 1954 graduate of Trinity University.

Grant K. Rauscher, Chemist, International Paper Co., South Glens Falls, N. Y., a 1949 graduate of Rensselaer Polytechnic Institute with a Ph.D. degree.

Lester H. Reinke, Product Development Engineer, Dow Corning Corp., Midland, Mich., a 1954 graduate of the University of Wisconsin.

J. Bert Rhyne, Assistant Chief Chemist, International Paper Co., Panama City, Fla., a 1949 graduate of Georgia Institute of Technology.

Russell L. Riley, Engineer, The Champion Paper & Fibre Co., Hamilton, Ohio. Attended Miami University, and the University of Cincinnati.

Elliot H. Rosenberg, Vice-President and General Manager, Thomson-National Press Co., Inc., Franklin, Mass., a 1955 graduate of Columbia University.

Ernest L. Ross, Student, North Carolina State College, Raleigh, N. C.

Mikio Sano, Manager, Gojo Paper Mfg. Co. Ltd., Yoshiwari City, Sizuoka Pref., Japan, a 1941 graduate of Kobe University.

Rocco P. Scalici, Director, Product Evaluation, Foster D. Snell, Inc., New York, N. Y., a 1940 graduate of Brooklyn College.

Ernest H. Schafer, Engineer, West Virginia Pulp & Paper Co., Covington, Va., a 1954 graduate of Battha sar Neumann Polytechnicum, Warzburg, West Germany.

Ulf V. Sjolund, Sales Manager, Pulp and Paper Machinery Dept., A. Ahlstrom Oy, Karhula, Finland, a 1949 graduate of the Technical College, Helsinki.

Edward H. Snider, Technical Control Superintendent, Canadian International Paper Co., Three Rivers, P. Q., Canada, a 1949 graduate of the University of Toronto.

Walter T. Stott, Research Physicist, The Metal Box Co. Ltd., Liverpool, England, a 1951 graduate of Leeds University.

Everett W. Streeter, Chemist, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1953 graduate of Norwich University.

Charles M. Swalm, Research Chemist, Campbell Soup Co., Camden, N. J., a 1942 graduate of the University of Pennsylvania.

Philip J. Swartzbaugh, Paper Chemist, P. H. Glatfelter Co., Spring Grove, Pa.

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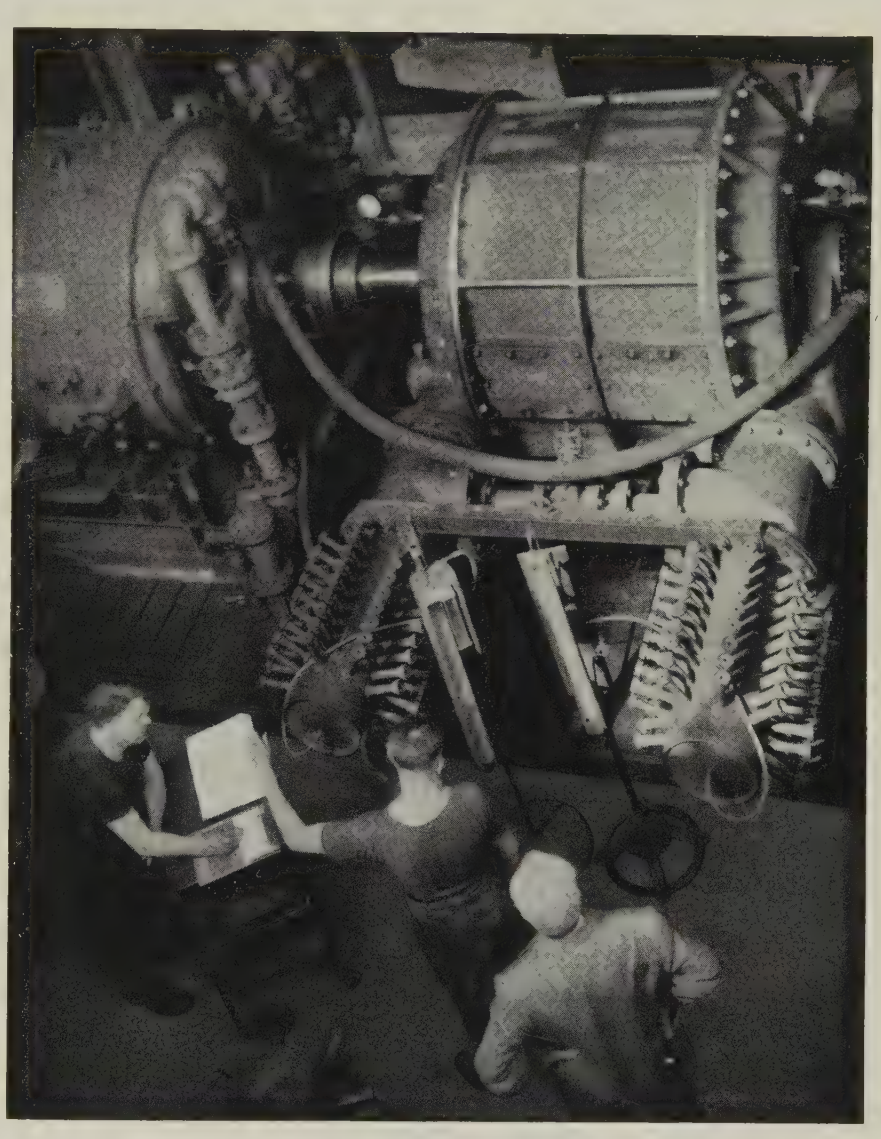

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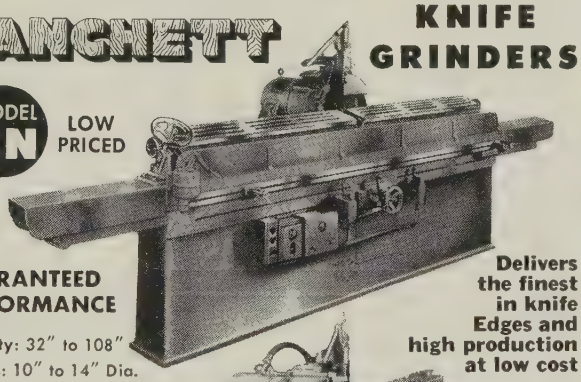

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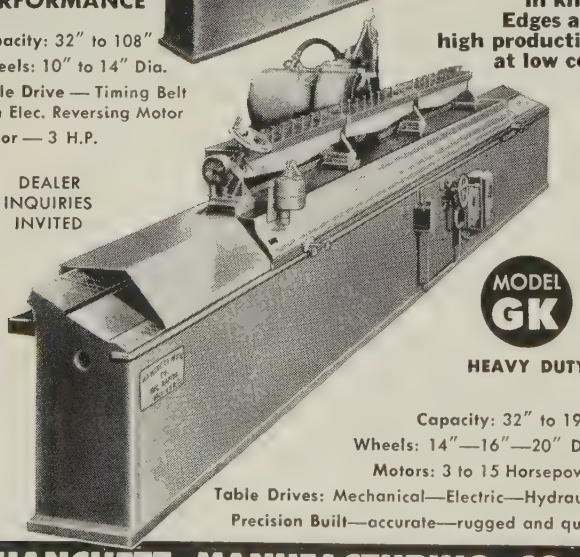

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Herbert Talboys, President, Talboys Instrument Corp., Emerson, N. J. Attended the Polytechnic Institute of Brooklyn.

Charles A. Tanner, Jr., Director of Development, The Glidden Co., Baltimore, Md., a 1933 graduate of the University of Virginia.

William W. Taylor, Technical Service Representative, Kraft Paper Div., West Virginia Pulp & Paper Co., New York, N. Y. Attended the University of Vermont.

Charles E. Varn, Branch Manager, Solvay Process Div., Allied Chemical Corp. New Orleans, La., a 1946 graduate of Virginia Polytechnic Institute.

Olavi Vilpponen, Export Manager, Oy Stromberg AB, Helsinki, Finland, a 1943 graduate of the Technical University, Helsinki.

Joseph Walker, Director, Petroleum Div., The Pure Oil Co., Crystal Lake, Ill., a 1950 graduate of the University of Wisconsin with a Ph.D. degree.

David Warren, Sales Engineer, Nash Engineering Co., South Norwalk, Conn., a 1942 graduate of Dartmouth College.

Lloyd A. Whittaker, Western Manager, Thomson-National Press Co., Franklin, Mass., a graduate of the Rhode Island School of Design.

William E. Wickham, Jr., Chief Laboratory Technician, MacAndrews & Forbes Co., Camden, N. J. Attended Franklin & Marshall College.

William Wight, Superintendent, Whakatane Board Mills Ltd., Whakatane, New Zealand.

George P. Wnuck, Plant Manager, Owens-Illinois, Paper Products Div., Aurora, Ind., a 1948 graduate of Illinois Institute of Technology.

Robert H. Zulch, Technician, Champion Paper & Fibre Co., Canton, N. C., a 1954 graduate of New York State College of Forestry.

TAPPI Notes

Tany Agronin is now President of the Appleton Machine Co., Appleton, Wis.

Stanton Allen is now President of Arizona Container Corp., Phoenix, Ariz.

Harold M. Annis is now Vice-President in charge of research for the Oxford Paper Co., New York, N. Y.

Bruce Armstrong, formerly of Jackson & Church Co., is now a Consultant to the University of Florida, Gainesville, Fla.

Jacob L. Barowsky is now President of the Adell Chemical Co., Holyoke, Mass.

Paul V. Barrow is now Production Superintendent of Penn-Mar Container Corp., Philadelphia, Pa.

Louis P. Cartsunis, formerly of Dorr-Oliver, Inc., is now in the Pulp and Paper Research Department of the Becco Chemical Division of Food Machinery & Chemical Corp., Buffalo, N. Y.

James T. Coghill, formerly of the Curlator Co., is now a Design Consultant to the Dilts Division, Black-Clawson Co., Fulton, N. Y.

Richard H. Cordingly, formerly a Student at The Institute of Paper Chemistry, is now a Project Chemist for the Pulp Division, Weyerhaeuser Timber Co., Longview, Wash.

Frederick A. Curtis is now Vice-President of the American Writing Paper Co., Holyoke, Mass.

Thage Dahlgren is now President of the Dahlgren Chemical Co., Conshoken, Pa.

James W. Davis is now Manager of the Paper Makers Chemical Research Division of Hercules Powder Co., Wilmington, Del.

Aarno J. Esila, formerly Superintendent of the sulphate

pulp mill of Kemi OY, is now with Metex Corp., Helsinki, Finland.

Roswell P. Fallon, Sales Service Representative of the St. Regis Paper Co., has been transferred from New York, N. Y., to Carthage, N. Y.

S. H. Grimnes, formerly of Ebasco Services, is now a Project Engineer for Cassell Associates, Ann Arbor, Mich.

William J. Hall, is now Assistant Kraft Mill Superintendent for the Weyerhaeuser Timber Co., Longview, Wash.

M. Sunarjo Hardjodarsono, formerly a Student at the New York State College of Forestry, is now on the faculty of the University of Indonesia Baranangsiang, Bogor, Indonesia.

John F. Hart, formerly of the Pulp and Paper Research Institute of Canada, is now Manager of the container plants of Longview Fibre Co., Longview, Wash.

Donald A. Hunter, General Production Manager of Diamond Gardner Corp., has been transferred from Plattsburg, N. Y., to Red Bluff, Calif.

William, H. Inman, formerly of Bloomer Bros. Co., is now a Research and Professional Engineer at 418 East Ave., Newark, N. Y.

William A. Kosicki, formerly of Scott Paper Co., is now Assistant Engineer for the Newport News Shipbuilding & Dry Dock Co., Newport News, Va.

Carl C. Landegger is now Assistant General Manager of the Black-Clawson Co., Watertown, N. Y.

Chester G. Landes, formerly of the American Cyanamid Co., is now with Wica Chemicals Inc., Charlotte, N. C.

William A. Leftwich, formerly of Riordan Sales Corp. Ltd., is now with the International Paper Co., Mobile, Ala.

Bengt Leopold, formerly of the Industrial Cellulose Research Ltd., is now in Charge of the Basic Research Section of the Mead Corp., Chillicothe, Ohio.

H. Clark Lind, formerly of the U. S. Army, is now a Research and Development Engineer for Texon, Inc., South Hadley Falls, Mass.

Kedwin R. Martin, formerly of the Fort Wayne Corrugated Paper Co., is now with the Olin Mathieson Chemical Corp. Forest Products Division, W. Monroe, La.

George S. McKnight is now Director of Research for the Oxford Paper Co., Rumford, Me.

William C. Miller, formerly with the Sorg Paper Co., is now a Paper Technologist for Clinton Corn Processing Co., Macon, Ga.

T. Richard Probst, formerly of the Brown Co., is now Executive Vice-President of the Deerfield Glassine Co., Monroe Bridge, Mass.

Arthur W. Redlin, formerly of Personal Products Co., has retired and is now located at 115 Richard St., Neenah, Wis.

Paul M. Schaffrath, formerly of Oxford Paper Co., is now Mill Manager for the Great Northern Paper Co., Millinocket, Me.

Lyle B. Schueler, formerly of the Diamond Power Specialty Corp., is now a Consultant at Coffin Point, Frogmore, S. C.

Earl W. Scott, formerly of Goodyear Tire & Rubber Co., is now Coordinator of Latex and Coating Development for the Marbon Chemical Co., Washington, W. Va.

G. Robert Sido, Technical Representative of the Monsanto Chemical Co., has been transferred from Washington, D. C., to Springfield, Mass.

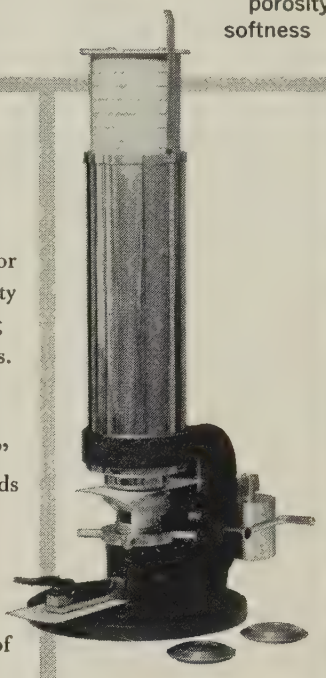
Clifford G. Thomson, formerly of the Bishop Asphalt Papers Ltd., is now Plant Manager of Murray-Brantford Ltd., Division of the Dominion Tar & Chemical Co., Ltd. Portneuf Station, P. Q., Canada.

Henning G. Waddell, formerly General Superintendent of Wifstavarfs A/B, is now with Kvarnsvedens Pappersbruk, Kvarnsvedens, Sweden.

Fred A. Weymouth is now Vice-President of the Interchemical Corp., New York, N. Y.

* * *

1 INSTRUMENT *for Testing* smoothness porosity softness



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Pacific Coast Representative

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E. T. McQuillan, Vice-President has succeeded *E. C. Reid* (deceased) as the official corporate representative of the American Writing Paper Co., Holyoke, Mass., in the Technical Association.

H. C. Church, director of process and product development has succeeded *A. G. Paine* as the official corporate representative of the New York & Pennsylvania Co., New York, N. Y., in TAPPI.

S. L. Visvanadhan, Managing Director, has succeeded *Ragho Raj Singh* as the official corporate representative of the National Newsprint & Paper Mills Ltd., Nepanagar, India in TAPPI.

* * *

Roderick E. Eddy has succeeded *J. A. Holmes* as the official representative of National Aluminate Corp., Chicago, Ill., in the Technical Association.

G. H. Crocker has succeeded *D. A. Johann* as the official representative of Roots-Connersville Blower Division, Connersville, Ind., in TAPPI.

H. W. Bates has succeeded *Robert Conway, Jr.* as the official representative of the Walworth Co. in TAPPI.

Industry Notes

Production

Paper and board production during October amounted to 2,879,786 tons. This was 3% above the 2,792,168 tons produced in October a year ago. Paper production amounted to 1,238,190 tons, compared to 1,200,777 tons produced in October a year ago, while the output of paperboard during this month at 1,346,399 tons, also reflected a 3% increase above the production of 1,302,138 tons reported for October, 1957.

Pulpwood

Pulpwood receipts at the pulp mills in October amounted to 3,405,887 cords, with consumption at 3,385,918 cords. Month-end inventories were practically unchanged at 6,122,321 cords.

Wood Pulp

Wood pulp production during October amounted to 2,080,606 tons as compared to 1,963,218 tons produced in October a year ago. Wood pulp consumption in the paper and board mills during October amounted to 2,140,435 tons, compared to the 2,041,779 tons consumed in October a year ago. Wood pulp inventories at the end of October at the paper and board mills amounted to 532,905 tons, as compared to 533,329 tons reported at the end of September. Month-end stocks of the pulp mills were 275,811 tons, as compared to 258,932 tons reported at the end of September.

Wastepaper

Consumption of fibrous materials other than pulpwood, totaled 898,170 tons in October, compared to 886,105 tons in October 1957. Inventories of 778,383 tons of month's end reflected a 2% decrease under end of September inventories. Consumption of wastepaper amounted to 802,762 tons, as compared to the 784,082 tons consumed in October a year ago.

Printing Research Conference

Lehigh University, Bethlehem, Pa., will be the site for the Fifth International Conference of Printing Research Institutes. Scheduled for June 8 to 13, 1959, the host is the National Printing Ink Research Institute, of which A. C. Zettlemoyer is research director and W. D. Schaeffer is assistant director.

"Color and Printing Inks" has been selected as the theme. A few papers of general interest in graphic arts research will also be accepted. Conferees are members of established research institutes in the graphic arts throughout the world. To keep the technical sessions on an intimate basis, only a limited number of other scientists can be accommodated. Those who have a positive contribution to make should address requests for participation to Program Chairman J. M. Fetsko of the NPIRI staff.

The four previous conferences were held in alternating years in England, Sweden, Holland, and Germany. In addition to representatives from most European countries, several delegates from Russia are planning to attend for the first time in the history of the conference. Japan and Australia are also expected to participate.

Financial aid to foreign delegates for travel has been provided by NPIRI, The Research and Engineering Council of the Graphic Arts, The Technical Association of the Graphic Arts, and The Institute of Paper Chemistry. Special events will be sponsored by the New York Printing Ink Manufacturers Assn. and by the American Newspaper Publishers Assn. Research Institute.

Pulpwood Research Association

Development of Lower Michigan's forest resource will get a further boost through incorporation of the Lower Michigan Pulpwood Research Association (LMPRA), said association President Roman J. Suess of the Otsego Falls Paper Mills, Otsego, Mich.

Articles of incorporation for LMPRA were filed January 5. Filer City was selected as the organization's headquarters.

Four other companies participating in LMPRA and their representatives to the association are: S. D. Warren Co., Muskegon, John N. Fields; Abitibi Corp., Alpena, A. J. Auden; Scott Paper Co., Detroit, Charles G. Allen; and the American Box Board Co., Filer City, Arthur P. Koller and Rowland W. Blair.

LMPRA, founded by officers of the five named pulp and paper companies, is devoted exclusively to the sponsoring of forest research and public instruction related to forest management.

Said President Suess: "Findings of statewide economic importance which resulted from the recent Phoenix Memorial Project aspen study conducted by The University of Michigan and financed by industry led our firms to join in underwriting continuing studies.

"The Phoenix deer-aspen studies opened a vast field of resource management which even today is affecting the economy of almost every portion of Michigan."

Through LMPRA funds will be provided by the participating firms, on a continuing basis, to universities, colleges, and other public and private research facilities to carry out designated research and education projects.

Association officials estimate that $15,000 will be available for research in 1959 in such fields as management and utilization of forests and forest products, watershed protection, game management, and recreational use of forest lands.

Abitibi

Abitibi Corp.'s modern and highly mechanized hardboard and insulation board mill is now in production at Alpena, Mich.

The mill is expected to produce over 200 million sq. ft. of board annually and is the only board mill in the United States making two kinds of hardboard (smooth-one-side and smooth-two-sides) and insulating board under one roof. As efficiently designed as any board mill in existence, it uses all the accepted commercial species of wood growing within its operating area.

Wood for the Alpena plant is secured mainly from 13 counties within a 100-mile radius of the mill site. This area is divided into three forest districts, each with a graduate forester in charge. Abitibi foresters offer a complete forest management service to land owners and hunt clubs, taking an active part in the state-wide tree farm program which is designed to

assure the continued development of quality trees, the improvement of property, and the maintenance of wildlife in the forests.

A distinguishing feature of Abitibi policy is the careful consideration the company shows for people working in the plant, for people living within its operating area, for the trees with which it works, and the wild-life which may be affected by its operation.

Exhaust ducts of the mill were designed so that fumes would not trouble nearby householders, and, before the plant was built, special studies were made of Lake Huron currents so that waste water could be scientifically disposed of without causing pollution. The waste water is passed through chemical and sedimentation treatments, the clarified effluent then being carried by pipe 1200 ft. out into the lake and finally diffused through special nozzles to avoid substantial depletion of oxygen in the lake waters.

The mill itself is a model of modern operation. Up to a point, the various kinds of wood intended for various end products are treated exactly the same, thus reducing over-all costs.

For instance, logs are brought to the mill by truck or rail in 100-in. lengths. They are unloaded and racked by Cary-Lifts, or a high-speed rubber-tired crane. The different species of wood are separated into three types: (1) pine and other conifers, (2) poplar, (3) other mixed hardwoods, and piled in alternate tiers. Normally, a two-month supply is kept at the mill and additional wood is piled in the woodlands, ready for delivery when required.

Cary-Lifts, moving a cord at a time, transport the wood to conveyors, which take it automatically to the barker house, where it is mechanically barked. The bark, which is not used in further operations, is shredded and sent to the boiler plant for consumption as fuel.

The logs pass to a 12-knife Norman 96-in. chipper where they are reduced to chips. The chips are carried by overhead belt to four 140-cord chip silos, each of which holds a different blend of wood chips. These are released from the bottom of the silo as required, making possible any desired blend.

The next step carries the chips to a 120-ft. digester tower which contains three automatic rapid-cycle digesters. The chips are exposed to variable pressure steam for varying periods, depending upon the product required, and are discharged into stainless steel live bottom blow bins.

Water is added in double disk refiners, the system so arranged that chips can be fed from any digester to any refiner, making it possible to blend the chips and use the best properties of different mixtures. The adding of water helps reduce the chips to fiber and the resulting wood pulp is sent to a refiner chest and then pumped to one of two washers.

These are conventional Oliver rotating drum washers where the formed sheet of wood pulp is showered with hot water to remove objectionable dissolved solids. Water, controlled in quantities by consistency regulators, is then added.

The mixture, containing about 96% water, is pumped to secondary single disk refiners where it is further refined to improve strength and other properties, and sent on to a storage chest.

Up to this point the manufacture of all three basic products is similar, varying only in the type of wood used, the cooking temperatures and times, refiner settings, etc. The process of reducing wood to pulp has been completed and further manufacture is designed to put the pulp back together into boards of different types having varying characteristics and uses.

For manufacturing SlS (smooth-one-side) hardboard, chemicals are added to improve the water resistance and the working quality of the finished board. The pulp is diluted until it is 98½% water and is passed through chemical mixing and storage chests. In the next step, sheets 4 ft. wide are made on a conventional fourdrinier forming machine consisting of an endless screen traveling over a series of rolls and vacuum suction boxes. Some of the water from the pulp flows away through the screen, leaving a sheet of chemically treated wood fibers on its surface. Still more water from the pulp is removed when the screen passes between a series of press rolls. The sheet is finally discharged with a moisture content of 60 to 65%.

Cut into oversize 16-ft. lengths, the sheets on traveling screens are loaded into a 20-deck elevator and then enter a steam-heated press. Highly polished stainless-steel caul plates press against the top of each sheet, providing the finished hardboards with smooth top surfaces. The bottom surfaces bear the imprint of the forming screens.

Under high temperature and a pressure of thousands of tons, a chemical reaction occurs between the wood's natural resins and the chemicals added during processing, resulting in a tough, grainless, semiplastic sheet of far greater uniformity than the original wood.

After unloading, the board can be further processed to become tempered hardboard, designed specifically for use in extremes of moisture and temperature conditions. This latter stage can be by-passed, the result then being standard hardboard.

All hardboard is finally treated in ovens at high temperatures for extended periods, then cooled and humidified to about 6% moisture content to stabilize its dimensions and prevent warping. Finished board is later cut to any desired rectangular size and scored or beveled in many different patterns for decorative effects.

The basic mat for S2S (smooth-two-sides) hardboard is made on an entirely different forming machine which is also used to produce insulation board.

In this instance, different chemicals are added to the pulp and the mixture then goes to a precision-controlled fourdrinier former, equipped with a Deculator (to remove excess air from pulp), rotary suction boxes, and a combination of hydraulically weighted suction press rolls and solid press rolls. Sheets up to 13 ft. wide and cut in lengths up to 24½ ft., are loaded into a 10-deck continuous Coe drier more than 300 ft. long, with many miles of steam coils between the decks.

This machine is enclosed within insulated panels and has 7000 individually chain-driven rolls on which the board rests. Huge fans circulate hot air, reducing the moisture content of the board to about 4%. Next, a double-arbor two-pass trimmer automatically cuts the board into 4 ft. widths and cross-cuts them to any desired length. An interesting feature is that the second pass of this trimmer can discharge board either to the left, for insulation board, or to the right, for manufacture into S2S hardboard.

For decorative insulation board, light-colored baseboard is used and a prime coat is applied at the forming machine. The dried board passes through a roll and brush paint applicator where a finish coat of paint is applied. It then goes through a steam-heated paint drier to a retrimmer, where it can be cut into large sizes for building board or small blanks for decorative tile. If the product is to be building board, it is now wrapped; if tile is to be the final product, it goes to a double-pass machine where the special concealed nailing tongue and groove joint is applied to all four edges. The finished tile is then loaded into Hand-Pac Abitibi cartons and sent to the warehouse.

Board for insulating sheathing passes from the double trimmer over an automatic jump transfer to a second conveyor line and through a double-end tenoner for application of tongue-and-groove edges. Board for sheathing and other exterior uses is impregnated, coated with asphalt and branded with the distinctive Abitibi logo. Board for roof insulation passes over another jump transfer to a third conveyor, is spread with glue for laminations up to 4 in. thick and goes to a cold laminating press.

In making S2S hardboard, the specially prepared base sheets pass through the double trimmer, are discharged to the right in oversize 4 by 16 ft. sizes and go to a conditioning oven where they are preconditioned to temperature and moisture. They

enter the loading elevator, 14 at a time, and then the steam press, where they are subjected to thousands of tons of pressure while exposed on both sides to highly polished, steam-heated platens. This gives them smoothness on both sides. Tempered board receives special treatment after leaving the presses, and then both types, tempered and standard S2S, undergo the same baking and humidifying process as S1S hardboard.

The Alpena plant of Abitibi Corp., in addition to being the most versatile in the industry in product, thus is also one of the most mechanized.

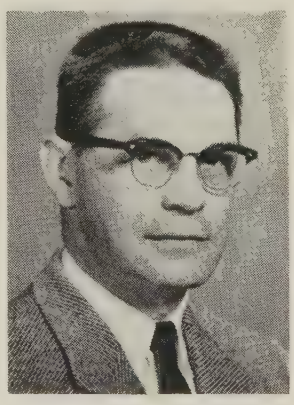
A separate building houses the power plant which consists of two modern coal-fired boilers generating steam at 900 lb. pressure, fired through spreader grate traveling stokers. Wood bark and dust from hardboard fabricating machines are fed into the furnaces as secondary fuel. In the power plant, a large turbogenerator produces most of the electricity needed by the mill.

Much of the process steam for the mill is obtained by extraction from the steam turbine. All water is obtained from the Thunder Bay River and chlorinated before use. Purity of water for the boilers is ensured by processing through a zeolite system. The boiler house also contains air compressors for the plant and a special compressor for instrument air.

Abitibi Corp.'s new Alpena mill breaks new trails in the wood products industry and is a credit to the community in which it is situated.

Great Northern

Paul M. Schaffrath has been appointed mill manager of the Millinocket mill of Great Northern Paper Co., effective Jan. 1, 1959.



P. M. Schaffrath, Great Northern Paper Co.

Mr. Schaffrath is 42 years old, a native of Syracuse, N.Y., a graduate of the Syracuse public schools and the New York State College of Forestry.

Following graduation he was head of the paper standards and inspection department of the New York and Pennsylvania Co., and later was for several years in charge of specialty paper development for Howard Paper Mills of Dayton, Ohio. In 1948 he returned to Syracuse where he was in charge of the research program which resulted in the development of the chemi-groundwood process of pulping hardwood, of which Great Northern has the first commercial installation. For the past seven years he has been associated with the Oxford Paper Co., of Rumford, Me., his most recent position being director of research of that company.

12th Bolton Awards

"I Want to Be Kept Informed" is the subject selected for the 12th Bolton Award according to an announcement made by the joint sponsors of this annual essay contest, The American Pulp and Paper Mill Superintendents Association and John W. Bolton & Sons Inc., of Lawrence, Mass.

As has been the case in all preceding awards, the contest period extends from January 1 to midnight March 31. Entrants are asked to submit their papers typed, double spaced on plain sheets, $8^1/_2$ by 11 in. and confined to approximately 1500 words. Cover sheets *only* are to include the author's name, name and address of the mill, home address, and job title.

All papers are to be mailed to the Secretary and Treasurer, The American Pulp and Paper Mill Superintendents Association, 327 South LaSalle St., Chicago 4, Ill.

Selection of this year's subject was made because of the general interest held by all members of the pulp and paper industry, regardless of the job or position held, in the matter of company communications. Interest in being "kept informed" places high on the list of all who seek efficiency in their work. A veritable storehouse of information on internal communications is anticipated within the scope of this subject.

$3650 in cash prizes will be awarded to 10 winners from the pulp and paper mill employees of North America. Top prize will be $1000, second, $750, and third $500. In addition there will be seven prizes of $200 each.

The ten Bolton Award winners will be announced at the Superintendents Association 40th National Convention to be held at the Shamrock Hilton Hotel, Houston, Tex., in early June. Winning essays will be published in the 12th Bolton Award Book and distributed throughout the industry in fulfilling the basic concept of the essay contest; namely, "to foster a free exchange of ideas on matters of common interest among members of the pulp and paper industry."

Continental Can

Continental Can Co., early in 1959 will begin construction of a 350-ton-per-day bleached sulphate paperboard and paper mill on the Savannah River near Augusta, Ga., General Lucius D. Clay, chairman of the board, announced. The mill is expected to be in operation in early 1961.

General Clay explained that Continental, which spans the entire range of packaging products and materials, will consume the bulk of the new mill's output in its own manufacture of folding cartons, plates, cups, and other paper containers, and will offer the remainder for outside sale.

Continental, which now operates three southern kraft mills and eight boxboard mills, does not currently produce its own bleached paperboard, although it converts bleached board purchased from outside sources.

The mill will be located on a 2600-acre site, on the main line of the Georgia Central Railroad, 11 miles south of Augusta. Its pulpwood requirements will be supplied not only by its own timberlands in Georgia and South Carolina, but by nearby farmers and other woodland owners from whom it will buy logs.

"Continental's decision to make an investment of this substantial magnitude in a bleached foodboard mill is based on the expectation that this product will continue to be the fastest growing segment of the paperboard industry for several years to come," General Clay said.

"The Augusta site has been selected with a view to future expansion. With an ample water supply, abundant space, close access to sources of both hardwood and softwood, and a good labor market, this location could support sufficient production to fully meet Continental's requirements for bleached products over a long period of time."

The initial 350-ton-per-day capacity of the new mill will be provided by a 216-in. trim fourdrinier paper machine already on order from the Beloit Iron Works. The plant design, however, lends itself to step-by-step expansion.

Engineering design and purchase of equipment is in progress at Continental's Greenville, S. C., engineering office of the Robert Gair Paper Products Group. J. E. Sirrine & Co. of Greenville is the engineering consultant.

Apart from the 400 employees at the mill itself, a large number of foresters, woodsmen, and others will be employed in the management of its woodlands and other wood procurement operations which will supply the mill's average pulpwood requirements of about 700 cords a day.

A 25,000 kw. power plant, adequate to supply the electrical needs of a community of 75,000 persons, and a 25,000,000 gal. per day water treatment plant will serve the mill. All

waste water from the mill will be treated in oxidation lagoons totaling 900 acres in expanse, to achieve major elimination of pollutants before the water is returned to the Savannah River.

Bowaters Southern

Bowaters Southern Paper Corp. produced its first millionth ton of newsprint December 31. This milestone was achieved on the new No. 4 paper machine which came into operation on December 18, just a few days prior to this occasion.

The start-up of the new no. 4 paper machine was a particularly outstanding achievement in the paper industry. This 276-in. machine was actually put into initial operation at a speed of 2035 f.p.m. The time consumed from stock on the wire to sheet on the reel was but 80 min., and the first reel was sufficiently good to be wound off on the machine winder. The machine is capable of an operating speed of 3000 f.p.m. and is also equipped with a twinver press section.

A duplicate size no. 3 paper machine was brought into operation in January, 1957, and the speed of this machine was gradually increased over the succeeding months which enabled a new world production record to be established on Dec. 18, 1957. On this date, this machine produced 380.3 tons for the 24-hour period, at a machine speed of 2446 f.p.m., trim width of 251.2 in., pounds per inch of trim of 2984, and a machine crew efficiency of 95.3%. During an experimental speed trial which was made on Sept. 17, 1958, this machine attained a maximum operating speed of 2510 f.p.m.

The start-up of no. 4 marked the completion of the second major expansion program since the mill was completed in July, 1954.

Oxford

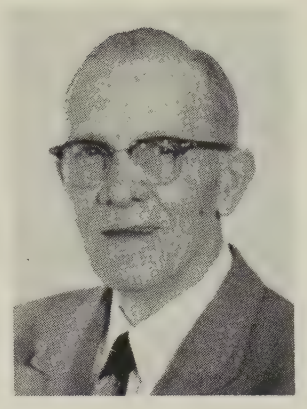
The promotion of two key mill executives at Oxford Miami Division of Oxford Paper Co., West Carrollton, Ohio, has been announced by Charles H. Claypool, mill manager.

Robert E. Beckett, general superintendent of the Oxford Miami Division, has been promoted to the position of paper manufacturing assistant to the mill manager. In his new capacity Mr. Beckett will work closely with the mill engineering department in design and planning. He will also function in an advisory capacity on paper manufacturing matters. Mr. Beckett joined Oxford Miami in 1915. He was machine tender on no. 1 and no. 3 machines and in 1932 he was named night superintendent. He was named general superintendent in 1943, a position he held until his promotion last week to paper manufacturing assistant to the mill manager.

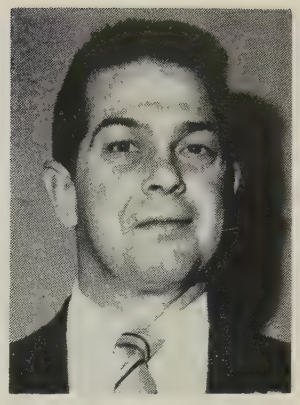
The promotion of James H. Ozias from assistant general superintendent to general superintendent of Oxford Miami Division was also announced. As general superintendent Mr. Ozias will have operating and administrative responsibility and control over the production organization and facilities of Oxford Miami Division. Mr. Ozias joined Oxford Miami in 1946. After functioning as production control supervisor he was named assistant general superintendent in 1955. Mr. Ozias is first vice-chairman of the Miami Valley section of the American Pulp and Paper Mill Superintendents' Association and he is a member of Ohio TAPPI.

G. S. McKnight, Oxford Paper Co.

Both promotions follow closely a series of other important changes in the organization of Oxford Miami Division. Recently, B. L. Merriss was named chief engineer of the division. He was succeeded as plant engineer by John Cavey. In other recent promotions at Oxford Miami, Harold Stevens was named superintendent of power, Richard Meyer was named finishing division superintendent and Morton Beece was named production control supervisor.



R. E. Beckett, Oxford Paper Co.



J. H. Ozias, Oxford Paper Co.

George S. McKnight, Rumford, Me., has been appointed director of research for the Oxford Paper Co. in Rumford, Me., it was announced recently by W. H. Chisholm, president of Oxford.

Mr. McKnight succeeds Paul M. Schaffrath, also of Rumford, who resigned from Oxford to become mill manager for the Great Northern Paper Company, Millinocket, Me.

Mr. Chisholm said that Oxford regretted losing such a capable research director as Paul Schaffrath but understood the attraction of the opportunity offered to him by Great Northern.

George S. McKnight was born in Brooklyn, N. Y., and is a graduate of Dartmouth High School and has a degree in physical chemistry from Dalkousie University. He joined Oxford in 1945 as a senior research worker with the research department. In 1949, he was promoted to a group leader with the same department and has been assistant director of research since late 1953.

St. Regis

Rhinelander Paper Co. merged into St. Regis Paper Co. and was established as a separate division of St. Regis effective Jan. 1, 1959. The new division will be operated as before under the direction of all the former officers of the merged company. They are as follows:

Folke Becker, chairman
Benton R. Cancell, president
W. R. Haselton, vice-president—operations (general manager)
W. J. Davis, vice-president—sales
J. H. Fennema, vice-president and treasurer
M. J. Kobernat, comptroller
Ruth Neumann, secretary

The head sales office will be at Rhinelander, Wis.

St. Regis Paper Co. announces that it is making its initial investment in the expanding economy of South Africa by the acquisition of a 50% stock interest in a centrally-controlled group of container manufacturers in the Union.

The three companies, and their subsidiaries, which operate three plants—two in Johannesburg and one in Durban—are Transvaal Box Manufacturing (Pty.) Ltd.; National Containers (Pty.) Ltd., and Atlas Box Co. (Pty.) Ltd.

The associated organization, whose annual sales volume is currently in the neighborhood of $5,000,000, manufactures and markets corrugated containers and a wide range of folding boxes and setup boxes, for which it enjoys a steadily growing market.

Plans provide for the business of the South African group to be continued under the existing management which has

built the business successfully during the past 23 years, with St. Regis to have equal representation on the various boards.

The South African container units will be supplied with the high quality linerboard produced at the St. Regis new mill at Jacksonville, Fla. Furthermore, important technical aid will be provided by the St. Regis organization, which should considerably assist in plans for expansion in present and allied products by the South African group.

Aron Fruman is chairman of the South African group, while Neville Edley is managing director of the Durban organization.

Rhinelander

Rhinelander Paper Co., a division of St. Regis Paper Co., announces the completion of a $4.5 million modernization project to improve both steam and electric generating capacity at its Rhinelander, Wis., location.

Begun in the spring of 1957, the project includes the construction of a new building to accommodate a new boiler a water treatment plant, and a turbine generator of the extraction back-pressure type.

The addition to the Rhinelander plant is a modern building, built of concrete, steel, and transite, is 58 by 71 ft. in size, and is 127 ft. high. The new boiler, costing $1,320,000 without auxiliary equipment, has a capacity of 260,000 lb. of steam per hour at 1500 p.s.i. at 950°F., and is capable of evaporating 600 gal. of water a minute at full capacity.

A water treatment plant, costing approximately $160,000, has been erected adjoining the boiler plant. It filters and demineralizes water from the Wisconsin river.

A turbine generator of the extraction back-pressure type has also been installed as part of the new system. It has a rated capacity of 10,000 kilowatts at 12,500 v. It takes steam at 1500 lb. pressure, extracts it at 400 lb. pressure and exhausts at 125 lb. pressure. Cost of the basic turbine and generator was approximately $579,068.

Rhinelander Paper Co. manufactures glassine and greaseproof papers.

Ohio Boxboard

American Box Board Co., Grand Rapids, Mich.; Central Fibre Products Co., Quincy, Ill.; and Ohio Boxboard Co., Rittman, Ohio, in a joint statement December 15, announced plans to merge their companies.

The announcement said the plan for the merger, with the approval of each company's board of directors, will be presented to the stockholders of each company as soon as necessary details can be worked out.

All three companies have been eminently successful in the packaging products field in their respective areas. They are not essentially in competition with each other. The consolidation will bring together facilities producing jute and kraft linerboard, boxboard, bleached kraft, corrugating medium, molded pulp products, egg packaging products, shipping containers, and folding cartons in an area stretching from New York to Utah.

Charmin

Pollution from its sulphite pulp mill has been cut in half within the past four years, the Charmin Paper Products Co. told the state in its year-end report to the Committee on Water Pollution.

Efficiency of the company's $3,000,000 torula yeast plant rose from 20% two years ago to 32% last year and is now 48% in removing the oxygen consuming materials from spent sulphite liquor before release to the Fox River. Supplementary processes boost the present year-round average to 51%.

"Further improvement is possible with existing facilities as we continue learning how to improve our operating techniques," declared M. J. Auchter, Charmin vice-president. "Operating data show all efficiencies are continuing to increase which will result in higher percentages of removal."

Charts and tables in the 85-page year-end report show that Charmin has brought down all other forms of pulp and paper mill pollution to well within the limits required by the state. The company is not only improving its abatement each year on sulphite liquor, but is also conducting pilot-scale experiments and detailed examinations of other processes which offer promise of supplemental usefulness in the future. It therefore requests the state's approval for continuing to work along present lines which are yielding steady improvement.

West Virginia

West Virginia Pulp and Paper Co., will equip a second paper machine for producing Clupak paper, increasing total capacity for this product to more than 150,000 tons annually, it was announced Dec. 9 by David L. Luke, president.

The company, presently the world's only producer of the product, began manufacturing Clupak paper early in 1958 after its new no. 3 machine at Charleston, S. C., was equipped with the first extensible unit. The second unit will be installed on the mill's no. 2 machine.

Mr. Luke said that the company decided to go ahead with the installation of a second unit as a means of serving the constantly growing requirements of present markets, and to meet the needs of future markets as more uses for the tough new paper are developed.

Because of the company's experience in installing and operating the first extensible unit, he said he expects the new equipment will be in operation within 30 days. With both units in operation, West Virginia will be able to supply its customers with more than 150,000 tons of stretchable paper annually.

Although production of extensible paper is presently limited to kraft grades, additional applications extending to a number of grades of paper are being developed by West Virginia research and product development teams. These teams are also carrying out continuing projects aimed at further improving the tough, workhorse characteristics of the basic products.

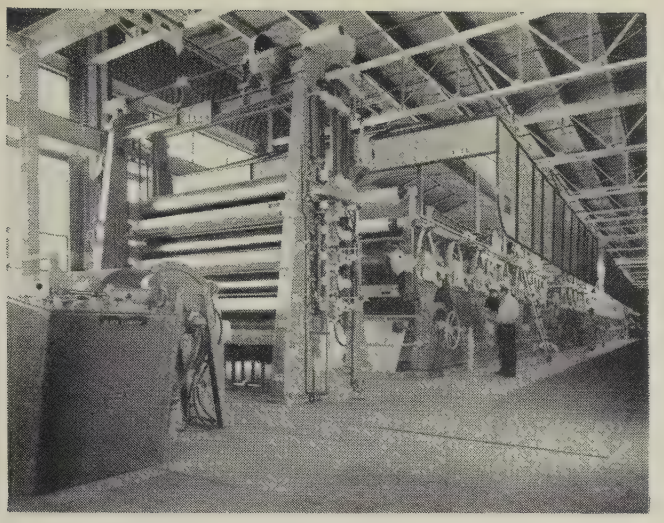
When stretchable paper was first introduced early in the year, it was announced that other paper manufacturers would be licensed to produce Clupak paper so that its benefits would be widely enjoyed. Two other major paper producers have recently been licensed through Clupak, Inc., and other major producers are expected to sign agreements in the near future

Hamilton

A major expansion program started nearly two years ago by Hamilton Paper Co., Miquon, Pa., (on the Schuylkill River just northwest of Philadelphia), reached its final stage as their no. 8 paper machine, christened *Hugo*, began operation recently.

The Black-Clawson machine named in a contest conducted among the Hamilton employees, was designated *Hugo* in honor of Hamilton's board chairman, Hugo H. Hanson. *Hugo*, selected unanimously by the judges from more than 400 entries, seemed to be a particularly appropriate tribute to the forward-looking leadership of Mr. Hanson during his more than 30 years with Hamilton.

A noted producer of fine papers (the largest in the text paper field), Hamilton's current expansion is particularly significant in that it dramatizes clearly the tremendous improvement in papermaking over the past century. This one new machine permits the retirement of two of the existing seven machines and even so, provides for an over-all production increase of more than 30%. The Black-Clawson machine operating at 1200 f.p.m. will produce upwards of 140,000 lb. per day of a wide variety of high quality papers. In comparison, Hamilton's first machine intalled in 1856 produced only 3000 lb. per day.



New fourdrinier at Hamilton Paper Co., Mcguire, Pa.

This whole expansion program, planned logically so that each segment would provide the supplemental facilities needed for further expansion, started in April, 1957, when ground was broken for a major addition, a warehouse providing new paper shipping facilities and more than 60,000 additional square feet of finished paper storage area. Provision was made for additional pulp handling capacity and new power and steam generating facilities in the form of a new 900 p.s.i. 875° boiler of 70,000 lb. per hr. capacity. This oil-fired automatic unit replaced two coal-fired semi-automatic stoker units of lower capacity and efficiency and provided sufficient additional steam generating capacity to carry the new stock preparation facilities and the new paper machine.

Following this development an additional Black-Clawson stock preparation system and storage facilities was provided including new refiner capacity in the form of two jordans and two additional Hydrafiners to provide the additional stock preparation capacity needed for *Hugo*.

Work on this phase of the program started November, 1957, and was completed and in operation by November, 1958.

New cutter room facilities were the next important phase of this integrated expansion program. These went on concurrently with other work and included a new 100 in. Harris Seybold trimmer, back feed, and conveyors for more accurate trimming and more efficient operation.

The culminating point of this basic expansion was, of course, the new paper machine which made all the other portions of this expansion program pay off in increased production and improved quality.

The new paper machine was built by the Paper Machine Div., Black-Clawson Co., Watertown, N. Y. It is designed to operate at speeds of 400 to 1200 f.p.m. All rolls are balanced for 1300 f.p.m. operation.

The machine is equipped to produce bond, offset, and reproduction papers in accordance with the most modern practices. It will manufacture from 70 to 80 tons per day.

The delivery and erection of this machine established at least two records in the field of fine paper machines:

1. By special arrangement it was possible to deliver every component of the new machine via truck shipments from Watertown to Miquon.

2. A machine erection speed record was set on this job—59 days from laying of sole pates to completion of machine erection.

Scott

Scott Paper Co. will make a substantial addition to its present Everett operations through construction of a new finished paper product warehouse and shipping building, it was announced on December 29, by Loren V. Forman, general manager of Scott West Coast operations.

The new building will be located adjacent to the present Scott mill, on the Southeast corner of the property in the area between the Great Northern Railroad and Federal Ave., and between extensions of Everett Ave., and 26th St.

Architect's drawing of new paper warehouse and shipping building, Scott Paper Co., Everett, Wash.

Due to recent developments in marketing policies and techniques, new demands on the Scott Traffic Division cannot be economically met with existing distribution facilities. The current consumer demand for color, multiple-roll packages, assorted colors, and new products has resulted in a very substantial increase in the number of Scott products in distribution. Consolidation of mill and warehouse will effect many advantages in filling complex orders, thereby providing more efficient customer service in the more than 11 western states served by the Everett plant.

Scott's new West Coast distribution center will be a three-story structure of reinforced concrete, erected on concrete pilings and covering approximately 90,000 sq. ft. on each floor. The building will be constructed in a T-shape, 431 ft. across the top and 398 ft. from top to bottom.

Believed to be one of the largest paper warehouses and shipping installations in the Northwest, the building will have facilities for simultaneous loading of 12 freight cars and six trailer trucks.

Transfer of a deed from Scott Paper Co., Chester, Pa., to the State of Maine Park Commission, was accepted by Governor Edmund S. Muskie in Augusta, December 29, assuring a new park in the Lily Bay section of Moosehead Lake.

Vice-President James L. Madden, Chester, Pa., handed the deed to the governor. Park Director Lawrence Stuart represented his commission. Scott officials, Curtis M. Hutchings, director, Bangor, and G. Donald Ellis, Woodlands manager, Waterville, were present with Madden.

Stuart said recent approval of $3700 contingent fund money by the governor and council would enable the commission to start preliminary work on the new development.

"We hope to open a public landing on Mud Brook Point, to construct a few picnic tables, install limited toilet facilities, and thus accommodate a few people next summer."

Scott originally offered the state some 300 acres of land at Moosehead Lake and later increased this offer to 576 acres. The Park Commission and subsequently the governor and council accepted the offer with "deep appreciation." Stuart said that the area includes about four miles of shoreline and off shore islands.

Crystal Tissue

A lightweight paper tissue that combines flame retardancy

and high wet strength has been developed through special processing techniques, and is expected to find many industrial, institutional, and home uses.

Classified as an 8-lb. tissue, this new material, produced by Crystal Tissue Co. of Middletown, Ohio, has found a unique application in the manufacture of treated top covers for disposable mattress pads used by hospitals and other institutions to minimize mattress wear. The pads consist of three layers—a top cover, an absorbent cellulose center, and a bottom layer of waterproof paper.

Many hospitals require that the top covers of the pads be flameproofed to protect against injury and damage caused by accidentally dropped cigarettes. With Crystal's new process, these top covers can be made of light tissue treated with Du Pont's "X-12" flame retardant at a savings of 30 to 40% over the nonwoven fiber cloth previously used, it is claimed. High wet strength is also incorporated to prevent the tissue from adhering to the patient's body.

To date, the biggest customers for pads with treated tissue covers have been V.A. hospitals.

Apart from this hospital use, an even greater potential market may be developed for flameproof tissue in Christmas and party decorations. Du Pont's "X-12" flame retardant is by no means the only property-giving ingredient that can be utilized by Crystal's process. Many other additives such as wet strength resins, corrosion inhibitors, fungicides, bactericides, and antioxidants can also be incorporated.

P. Andrew Jackson

P. Andrew Jackson retired from active duty Dec. 31, 1959 after serving 12 years as field erector, consultant, engineering and sales engineer for Pusey & Jones Corp.

Mr. Jackson's first paper mill experience dates back to 1906 with Dupont company's experimental pulp keg department, in 1907 he joined the Pusey Jones Co. engineering department in 1907 and left in 1917 to go with American Writing Paper Company of Holyoke, Mass., for 25 years, the last 16 years was in the capacity as chief engineer. He returned to Pusey & Jones after being with Eaving Paper Mills five years as vice-president in charge of engineering and production.

J. W. Rouse

The John W. Rouse Construction Corp. of Gouverneur, N. Y., announces the appointment of T. E. Detcher as manager of sales, effective Jan. 1, 1959. Rouse Construction has completed many major expansion and improvement programs in the paper industry, and most recently executed an extensive construction program in connection with the expansion at Nakoscsa-Edwards Paper Co., Potsdam, N. Y.

T. E. Fletcher, John W. Rouse Construction Corp.

I.P.C.

A gift of $25,000 to the Institute of Paper Chemistry from the D. S. and R. H. Gottesman Foundation for the establishment of the D. Samuel Gottesman Loan Fund has been announced by John G. Strange, president of the institute, and Ira D. Wallach, president of the foundation.

The load fund, established to help students who would be unable to continue their studies without financial assistance, honors the memory of the late Samual D. Gottesman.

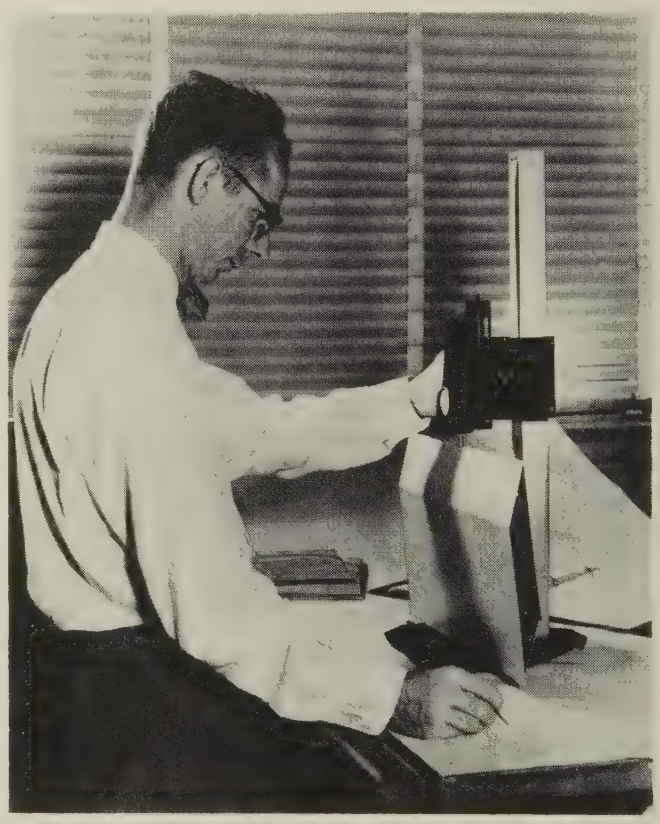
Mr. Gottesman, at the time of his death in 1956, was president of Gottesman and Co., merchants of wood pulp and paper, and the Central National Corp., investment bankers.

I-T-E

A compact, comprehensive new bulletin, No. 5004-1A, designed to aid in the selection of molded-case circuit breakers and enclosures has been published by I-T-E Circuit Breaker Co., Hamilton St., Philadelphia 30, Pa.

Hunter Spring

A simple, accurate test instrument, called the Hunter carton scorebend tester, has been developed by the Hunter Spring Co., Lansdale, Pa., to measure the force required to "break-open" flat folded paperboard cartons. The instrument is designed to help carton manufacturers control production quality and eliminate rejects, and to enable users of automatic cartoning machines to specify cartons to a recognized standard and discover "tough" cartons before they can cause filling line slowdowns and stoppages.



Hunter carton scorebend tester

The Hunter carton scorebend tester weighs about 11 lb. and has an over-all height of 26-in. Price of the tester, which includes one of the three interchangeable gages, is $195.00. The other gages are available at additional cost. Further information may be obtained from Apparatus Division, Hunter Spring Co., 1 Spring Ave., Lansdale, Pa., or from Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

Graver

A newly revised and enlarged bulletin, WC-106A, on tray-type deaerating heaters is now available from Graver Water Conditioning Co., 216 West 14th St., New York 11, N. Y.

Ingersoll-Rand

Ingersoll-Rand has introduced a new line of heavy-duty, medium-temperature process pumps, class SFLM, for handling temperatures to 300°F. and for pressures to 600 p.s.i.g.

The pumps are vertically-split, single-stage, single-suction units with overhung impellers. Capacities range up to 1400 g.p.m., heads to 650 ft. and discharge diameters are available in sizes of 1 to 4 in. The SFLM pumps are described in Ingersoll-Rand's 6-page flier Form 7494, that includes construction information, data on parts, interchangeability and a detailed cross-section illustration. The flier may be obtained by contacting the nearest Ingersoll-Rand representative, or Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y.

Westinghouse

A new 24-chapter, 650-page edition of Maintenance Hints handbook has been published by Westinghouse Electric Corp. The 5 by 7-in. leatherette-bound manual is designed to provide a quick, complete, and convenient guide to modern maintenance practices on all types of electrical equipment. For a copy of Maintenance Hints, send a $2 check or money order to Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Clinton Corn

Appointment of Roy L. Creamer, Jr., as district manager in charge of Clinton's new district sales office at 307 Merchants Exchange Building, 5100 Oakland Ave., St. Louis, Mo., has been announced by H. A. Bendixen, vice-president and general sales manager, Clinton Corn Processing Co., Clinton, Iowa.

General Industrial

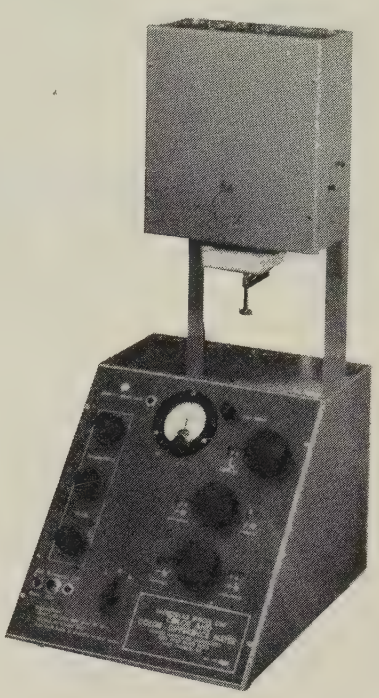
General Industrial Co. has just introduced a circular slide rule for engineers and for other plant and office executives. Any executive who must perform simple calculations will find this convenient, pocket-size calculator extremely useful

in his work. For your free circular slide rule, write on your business letterhead to General Industrial Co., 5738 Elston Ave., Chicago 30, Ill. To those of our readers who do not qualify as an engineer or other business executive to receive a free slide rule, General Industrial Co. will be pleased to send one for 50¢.

Hunterlab

A new instrument has been designed by the Hunter Associates Laboratory of McLean, Va., to measure the whiteness, reflectance, yellowness, and opacity of white and near-white paints, papers, textiles, ceramics, foods, plastics, and soap products. It can be equipped with an ultraviolet absorbing filter which may be alternated between the incident and viewing light beams to measure directly the contribution of the widely used fluorescent brighteners to specimen whiteness. The instrument uses paired vacuum tubes in a null Wheatstone bridge circuit. It employes a 45° 0° geometry and has green and blue tristimulus filters each with a separate pair of phototubes.

A precise, digital-dial color and color-difference meter has just been developed by the Hunter Associates Laboratory. The new instrument is intended primarily for small color differences found in the paint, paper, plastics, textile, soap,



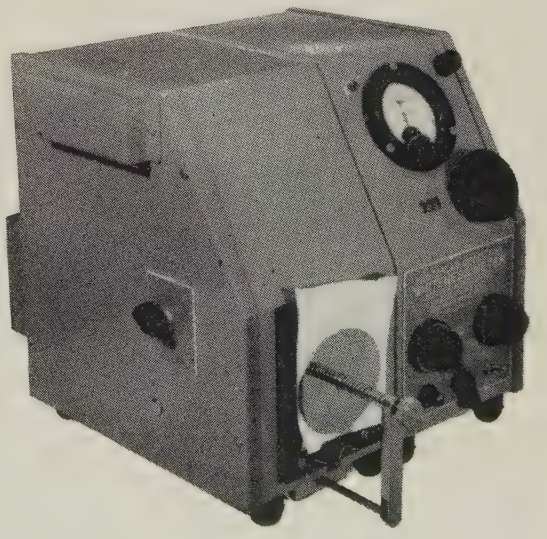
Hunterlab color and color-difference meter

ceramics, and food industries. It employs tristimulus filters and vacuum phototubes which are thermostated for maximum stability. The analog scales of the instrument have nearly the uniform visual spacing of the Munsell color system:

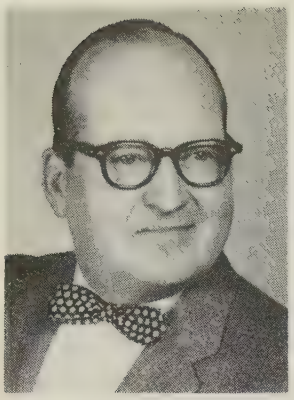
1. L measures lightness and varies from 100 for perfect white to zero for black,
2. a measures redness when plus, gray when zero, and greenness when minus,
3. b measures yellowness when plus, gray when zero, and blueness when minus.

With a ceramic hitching-post color standard close to the color of a product, accurate color measurements of this product can be made.

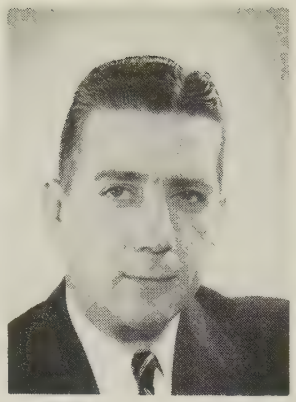
A detailed description of the new apparatus appears in the December, 1958 issue of the *Journal of the Optical Society of America.*



Hunterlab whiteness reflectometer



C. H. Butterfield, Pusey & Jones Corp.



T. T. Quigley, Wallace & Tiernan, Inc.

WALLACE & TIERNAN

The board of directors of Wallace & Tiernan Inc., Belleville, N. J., elected Thomas T. Quigley vice-president—equipment divisions at the December 4 meeting of the board. Mr. Quigley assumed his new duties on January, 1959. He will be responsible for all operations of the company's equipment divisions.

PUSEY AND JONES

C. H. Butterfield has joined the Pusey and Jones Corp. as a sales representative in the midwest.

U.S.I.

The technology of polyethylene plastic—from basic chemistry of the resins to fabrication of end-products—is described in a comprehensive 100-page handbook published by U. S. Industrial Chemicals Co. Petrothene® Polyethylene—A Processing Guide is believed to be the first work designed to tell the complete story of polyethylene in a single booklet with a minimum of repetitive detail and highly technical jargon.

Copies are available upon request to: U. S. Industrial Chemicals Co., 99 Park Ave., New York 16, N. Y.

HUYCK

Most recent among new developments stemming from Huyck Felt Company's extensive and continuing research at Rensselaer, N. Y., is a new, revolutionary chemical treatment called HUY-5. Developed especially to improve performance and increase service life of felts running high brightness board and market pulp, the new, all-purpose, natural color treatment gives felts outstanding resistance to wear, bacterial and chemical attack, shrinkage or felting, changes in running size and hair shedding.

The new HUY-5 chemical treatment has been thoroughly tested and proved by Huyck's laboratory and pilot plant operations and has undergone exhaustive testing afield in the past two years. A company spokesman stated that the need for the new treatment has been strongly expressed by operators of high brightness board and market pulp mills who have attended Huyck Felt Workshop sessions. Reports from mills producing food board, pulp, white patent coated and coated, bristol and mounting board, bleached manila, and bleached tag stock, prove conclusively, says Huyck, that the new HUY-5 chemical treatment is making a major contribution to increased production, improved product quality, and lower felt cost.

ALBANY FELT

The appointment of Perry H. Brown as director of quality control at the Albany, N. Y., plant of Albany Felt Co., has been announced.

TEXAS GULF SULPHUR

Texas Gulf Sulphur Co., 75 East 45th St., New York 17, N. Y., announces the appointment of W. B. Gillette and Bryan W. Guess as assistant sales managers.

LODDING

Lodding Engineering Corp., makers of doctors, doctor blades, fuzz removers, showers and oscillators for showers and doctors, is occupying its new plant in Auburn, Mass., nearby its former location in Worcester. The new plant, which is distinguished by its unique construction, provides ample room for the growing needs of this company.

SHAWINIGAN RESINS

A new 32-page technical manual on the properties and uses of Butvar, polyvinyl butyral, and Formvar, polyvinyl formal, has been published by Shawinigan Resins Corp. Copies of the booklet may be obtained on request from Department DD, Shawinigan Resins Corp., Springfield 1, Mass.

G.E

High-performance, precision gears from less than 1 in. to over 200 in. in diameter and with tooth-to-tooth spacing accuracies of 0.0002 in. are described in General Electric's new bulletin GEA-6430 available from General Electric Co., 1 River Rd., Schenectady 5, N. Y.

OBITUARIES

Ralph A. Masten

Ralph A. Masten, manager of International Paper Co.'s mill at York Haven, Pa., died on Jan. 27, 1959, at his home. He was 57 years old.

Mr. Masten was born in White Creek, N. Y. He graduated from Worcester Polytechnic Institute in 1923 and joined International Paper Co. in 1926 as an engineer at the company's Glens Falls office. He was named manager of the York Haven Mill in 1940.

Mr. Masten was active for many years in the Boy Scouts of America movement, served as a National Councilman and Past President of the York-Adams Council of the Boy Scouts of America and was a holder of their Silver Beaver Award. He was a member of the Masons and the Susquehanna Lions Club and of TAPPI since 1930.

Mr. Masten is survived by his widow, Mrs. Jennie J. Masten and by two children, Ralph Masten, Jr., and Mrs. George Peterson.

Funeral services were held on Friday, January 30, at the Ziegler Funeral Home in Manchester, Pa.

Lorne B. Mulloy

Lorne B. Mulloy died on Jan. 17, 1959, while on a business trip to Atlanta, Ga.

Mr. Mulloy was assistant vice-president and chief engineer of Haloid Xerox Inc. of Rochester, N. Y., coming with the company in 1946. Prior to this, he was with Hammermill Paper Co. in Erie, Pa., from 1925 to 1943, and with Allied Chemical and Dye from 1943 to 1946. He was a graduate of Clarkson University, Potsdam, N. Y. Surviving him is his wife, Louise O. Mulloy.

Mr. Mulloy became a member of the Technical Association in 1949.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Optical Properties Committee

A meeting of the Optical Properties Committee of TAPPI was held during the Ninth Testing Conference at the General Oglethorp Hotel at Savannah, Ga., starting at 9:30 a.m., Wednesday, Oct. 1, 1958. In the absence of Chairman Van den Akker, Vice-Chairman Hunter presided.

Due to the very recent and untimely death of Secretary Bellinghausen (on Sept. 6, 1958), we were without a secretary. Mr. Hunter asked Mr. Wiles to serve as secretary for this meeting. Some 21 persons were present for the meeting, eight being active members of the committee. Three or four others, noted on the registration list, showed a desire to become members.

As a first item of business a movement was made by Mr. Wink, seconded by Mr. Lang, and approved unanimously by those present, that a letter of appreciation and sympathy be sent to Mrs. Bellinghausen. Mr. Hunter agreed to dictate and send such a letter.

Mr. Obenshain as chairman of the Technical Services Group made the following observations:

1. Committee chairman should be limited to a period of 1 to 3 years in office. Mr. Van den Akker has now been in office close to 2 years and, we believe, has limited his term to 2 years. In order to be able to elect officers at the next (February) meeting, Mr. Hunter agreed in Van's absence to appoint a nominating committee at this meeting so as to be able to present a slate of officers for the February meeting.
2. The general committee should be supplemented by task forces, one representative of each task force should be from the Precision Committee.
3. All methods under each committee's jurisdiction should be reviewed at least once each 5 years.

The following groups and joint committees were reviewed:

Routine Control Committee

Mr. Wiles has not been able to get to any of its meetings but Mr. Hunter has done so and reported on the recent get-together. About 40 Routine Methods are now about ready for submission.

Graphic Arts Committee

Representative Wing absent.

Nonfibrous Raw Materials

No representative.

Paperboard Testing Committee

Representative Hudson absent.

Wax Testing Committee

Representative Paris absent.

Joint Advisory Committee on Printability

Representative Obenshain reported no action since last meeting. Some work is currently being carried out by this committee.

Joint Committees

ASTM D-6. Representative Silard absent and no other D-6 members present.

TAGA. Representative Obenshain was listed, but reported he believed this listing to be in error since he does not belong to TAGA.

ISCC. Representatives Obenshain and Hunter. The paper given by Mr. Hunter on September 30 was in effect a report on the activities of this group.

APPA. Representative Obenshain. This group has agreed to cooperate more fully in the future (presumably as regards APPA, sponsored Instrumentation Studied). Nothing further to report at this time.

Report of Subcommittees (now called Task Forces)

Project 144. Illuminants for Visual Grading and Color Matching. Representative Lang reported meeting at NBS on standards for integrators. NBS will put out standards (five items) at $250 per set. Someone from Optical Properties Committee should review ISCC news and literature and report periodically to us on anything of interest. Mr. Lang was asked and agreed to do this.

A paper on Lighting and Illumination for Color Matching is available from the Graphic Arts Industry. Methods are very critical and only Macbeth type illumination meets specifications. "Lighting for Color Appraisal" by Graphic Arts Institute, Inc., Washington, D. C.

Project 321. Standardization of 75° Gloss. Mr. Wink, replacing Mr. Bellinghausen. It should be worthwhile to distribute samples for round robin tests to see how present instruments agree. Instruments should agree within 1% full scale. New Gaertner instrument costs $3500, has many adjustable features perhaps unnecessary except in a research instrument; about 12 have been sold. The B & L instrument may be converted but is a complete rebuilding job. The method was sent out Aug. 29, 1958, and should have been in the hands of the membership before this meeting. Some report not having seen it. This Task Force should have a member from the Precision Committee.

Project 564. Brightness of Paper and Paperboard (T 452), Mr. Van den Akker. This method has been sent out and approved by TAPPI ballot.

Project 565. Opacity of Paper, Mr. Van den Akker. This method has been sent out and approved. Mr. Lang stated that the industry is more in need of an improved instrument for opacity than for gloss.

Project 566. Preparation of Test Method for the Chapman Smoothness Tester, Mr. Obenshain. Mr. Obenshain has not had time to write up this method. It was suggested that perhaps the method already published by Obenshain, *et al.* should be used as an interim routine control method.

Membership

Several of those at the meeting desired to become members and so indicated on the attendance record.

New Business

1. Does present method for brightness include fluorescent contribution? New and remodeled G.E. instruments are now so equipped and Mr. Wink reported a very high percentage of instruments now have been so remodeled. Present method however, makes no mention of this matter. Hunter

has new instrument to measure directly the effect of the fluorescent contribution.

2. Instrumental Variables in Brightness Testers. The Institute of Paper Chemistry has vast amount of data on this subject but it would be a monumental work to sort the data out and to analyze them.

3. Rating of Shade Difference in Dyed Papers. ASTM has methods on its books and much work has been done on this subject. Many instruments are available. Voted to leave in abeyance.

4. Nomenclature of Optical Properties in TAPPI Standards and Data Sheets. Considerable discussion on this.

5. Mr. Lang voiced the need for work concerned with show-through on paper. It was voted to initiate a task force to study the effect of show-through on paper. Lang, Schmutz, and Melsheimer all expressed an interest in this subject.

6. Short discussion on dirt but no conclusions reached.

7. J. D'A. Clark announced that the TAPPI Reference Pulp was now available and suggested that its field be broadened. Should not the Optical Properties Committee use this pulp for a round robin on optical tests (T 216, T 217, T 218, etc.). The following agreed to cooperate in such a round robin:

Hughes—West Virginia Pulp & Paper
Schoettler—Consolidated Water Power & Paper
Chapmen—PPRIC
Wink—The Institute of Paper Chemistry
Wiles and Lang jointly—Lang T-216, Wiles other tests.

The meeting adjourned at 12 noon.

R. H. WILES, *Acting Secretary*

Adhesives Testing Committee

A meeting of the Adhesives Testing Committee was held on Dec. 10, 1958, at TAPPI headquarters, New York, N. Y.

Members present: Neuss, Sederlund, Carey, Allen, Breslouf, Brown, Erikson, Faunce, Fischer, Godshalk, Minelli, Simonson, Weisenhoffer.

Visitors: Arch Doria, Ralph Green, Harold Ladue, and A. J. Winchester.

The meeting opened at 10 a.m. The minutes of the Sept. 17, 1958 meeting as published by the secretary were accepted.

The chairman reported on the results of his campaign to obtain a broader membership base, particularly in those adhesive lines not represented or where it was felt additional help was needed.

New members are: Ralph W. Allen, chief chemist, Cochran Foil, Louisville, Ky.; A. B. Cromwell, Union Paste, Hyde Park, Mass., Frank Fischer, Stein Hall & Co., Miss Dorothy Godshalk, Dixie Cup Co., Miss Elizabeth Weisenhoffer, Laminating Laboratory, Polymer Industries, Springdale, Conn.; Paul Yoder, Pyroxylin Products.

Correspondence with Mr. Yang indicated he would prefer to work on remoistenable adhesives and the chairman asked that Mr. Carey and Mr. Minelli keep him informed by submitting their work to Mr. Yang for review and comment.

The secretary read a letter from A. D. Little in which they expressed a willingness to cooperate with the committee by seeking clients' releases to publish any work that might be of interest to the committee. They requested further information on the committee's scope and some indication of our fields of interest. The secretary was asked to reply and to expedite securing any contributions Little clients might make.

The chairman read a letter from Mr. Winchester conveying the names of 44 attending the Testing Conference at Savannah who expressed an interest in the committee work. The secretary was asked to send each a copy of the committee's aims, a roster of members, and a copy of these minutes.

The chairman introduced the question of developing a test equipment for predicting the machine-ability of adhesives. Available laboratory tests are inadequate and some means must be found to correlate laboratory-scale tests with on-machine performance. The question arose as to whether TAPPI would appropriate money to design and build an adequate testing device. Mr. Winchester reported that the Research Appropriation Committee meets April 1 and that a formal request for funds should be processed through the Testing Division so as to reach that committee in March.

Adhesives Testing Committee: seated—Frank Fischer, Stein Hall; Dorothy Godshalk, Dixie Cup; William Neuss, Stein Hall, chairman; Elizabeth Weisenhoffer, Polymer Industries; J. P. Carey, Jr., Dennison Manufacturing Co., secretary. Standing: Morris Breslouf, Borden; Oscar V. Simonson, Milligin & Higgins; Arch Doria, "Adhesives Age;" A. J. Winchester, TAPPI; Harold J. Ladue, Pure-Pak Laboratories; Robert D. Faunce, Reynolds Metals; John J. Minelli Eureka Specialty Printing Co.; Carl Erikson, Arabol; William W. Sederlund, National Starch Products, vice-chairman

Mr. Erikson pointed out that Potdevin had a basic machine that might serve as a starting point for a testing device. Some means of removing adhesive and of adding fresh adhesive would have to be devised. Among other things, the number of rolls and their speeds should be variable and possibly a simulated picker-arm action should be added. It was agreed that a small group should determine just what properties are to be included under "machine-ability." Mr. Neuss accepted the task of preparing the list of properties and asked that those having ideas to contribute get in touch with him within the week. He will then discuss the problem with Potdevin to determine what might be done.

The chairman reported that Mr. Bearman would prefer to work with Mr. Sederlund on vegetable adhesives. The change was made as requested.

Mr. Erikson referred to some past work by Atlas Powder on sorbitol in adhesive formulations and suggested that they be asked to contribute. The chairman agreed to inquire.

Arch Doria of *Adhesive Age* magazine was an invited speaker. He referred to a study of the adhesive field made some 30 years ago, which found the field "chaotic." Palmerton Publishing Co. publishers of *Adhesives Age*, made a similar survey 10 years ago and found the field still chaotic. Palmerton launched the magazine this fall feeling like pioneers in a field they know little about. They are attempting to fulfill the function of the trade press to serve the manufacturer, the user, and the technical people. They estimate 40 major industries use adhesives as ingredients and doubt that there is a field not using adhesives. Mr. Doria mentioned that technical articles submitted usually require a little dressing up since they are directed at the principal readers, the nontechnical users. They wish to keep abreast of all new developments and to publicize them. The magazine can also serve as a forum or exchange of ideas on specifications standards, and test methods. The industry is practically

being forced to bring order out of the chaos, to arrive at a common understandable nomenclature, and test methods. Mr. Doria closed by requesting criticisms and suggestions that will improve the publication and its service. The chairman thanked Mr. Doria for his contribution and requested that he attend future committee meetings, if possible.

The question of format for monograph chapters was raised. The chairman referred to the suggested format given in the minutes of our December, 1957 meeting. Another style is that followed by Willetts, *et al.* in the paper loading monograph. It is not intended to set up any strict format at this time, and at the February meeting suggestions will be welcomed.

Harold Ladue of Pure-Pak Laboratories presented an adhesion problem regarding production of milk cartons from so-called low-wax board. It would appear that the various treatments given the stock at the mill to reduce wax requirement interfere with glueability of the board. Erikson suggested a test used by Dixie Cup to show rate of bond formation. Faunce discussed a test used at Reynolds to forecast behavior of paper in foil laminating. Arrangements were made for Mr. Ladue to obtain the necessary details. Mr. Faunce submitted a bond quality test method in the Routine Control method format for approval. Members not present will receive a copy with these minutes.

A subcommittee to handle foil-mounting problems was formed with Mr. Faunce, Mr. Allen, and Miss Weisenhoffer. They were asked to prepare their own working arrangements.

Miss Godshalk disclosed that Dixie Cup has a method for correlating wet tack and viscosity, having found that the Brookfield viscosity did not correlate well due to low rate of shear. At the chairman's request Miss Godshalk will inquire if Dixie will consider having a discussion of the method presented at the February meeting.

The chairman presented his report on the cooperative study of the Thwing-Albert tack tester. Members not present will receive a copy with the minutes and are asked to indicate their approval or disapproval directly to him.

The final business was selection of Feb. 24, 1959, as the date for the next meeting at a time and place to be announced in the National TAPPI program.

The meeting adjourned at 4:30 p.m.

Joseph P. Carey, Jr. *Secretary*

Routine Control Methods Committee

The first session of the R. C. Methods Committee was opened in the Wilmington Room at 9:30 p.m. In the absence of Chairman F. A. Delforge, Vice-Chairman J. B. Gunning presided.

The following members were present:

J. R. Gunning, Abitibi Pulp & Paper Co., Georgetown, Ont.
C. F. Brandon, Miami University, Oxford, Ohio
W. F. Bachelder, Testing Machines, Inc., Mineola, N. Y.
L. C. Aldrich, West Virginia Pulp & Paper Co., Covington, Va.
W. L. Cassiday, Alton Box Board, Alton, Ill.
M. P. Boland, Columbia-Southern Chem. Corp., Barberton, Ohio
L. J. Slentz, Solvay Process Div., Syracuse, N. Y.
D. R. Cushman, Socony Mobil Oil Co.
B. Q. Haynes, B. F. Perkins & Son, Holyoke, Mass.
A. J. Winchester, TAPPI, New York, N. Y.
R. S. Hunter, Hunter Associates Lab., McLean, Va.

Mr. Gunning opened the meeting by calling for a report by the Review and Revision Subcommittee. L. C. Aldrich gave the report in the absence of Chairman Charles Stump. He reported that he and Mr. Stump had completed and distributed a proposed Index and Numbering System. Since each committee member had received a copy of the report, Mr. Aldrich gave a detailed explanation of the indexing and numbering system and answered questions in regard to its use. Vice-Chairman Gunning and the other committee members commended Mr. Aldrich and Mr. Stump on the excellent job they had done in classifying and arranging the various methods according to use.

Jack Winchester, in behalf of TAPPI, then explained the merits of continuing the existing numbering system at TAPPI headquarters and asked that the committee consider using the new proposed numbering system for classification only. A discussion followed regarding the proposal. It was moved and passed that the new numbering system as submitted by the Review and Revision Subcommittee be converted to a subject index and that the existing TAPPI R. C. numbering system be continued at least until such time as the new indexing system could prove its superiority over the present system. It was further moved that the subject index, when prepared, be sent to all TAPPI members in the next mailing of R. C. Methods.

Progress reports were given by the following Subcommittee Chairmen:

Editorial Board—J. R. Gunning
Other Organizations Liaison—W. F. Bachelder

Reports of the following subcommittees were not given at this session because of the absence of their chairman:

Supplier Liaison—P. S. Cade
Instrument and Equipment—Clyde Eckhart
Organization Committee—L. H. Tyler

The session was adjourned at 11:15 p.m.

September 30, 1958

The second session of the R. C. Methods Committee was opened at 1:00 p.m. on Sept. 30, 1958, in the Wilmington Room following a luncheon served to the following committee members and guests:

F. A. Delforge, Continental Can Co., Uncasville, Conn.
C. E. Brandon, Miami University, Oxford, Ohio
A. J. Winchester, TAPPI, New York, N. Y.
P. W. Bartholomew, M. & O. Paper Co., International Falls, N. Y.
P. E. Nethercut, TAPPI, New York, N. Y.
James d'A Clark, Victoria, B. C., Canada
D. Noel Obenshain, West Virginia Pulp & Paper Co., Luke, Md.
W. L. Cassiday, Alton Box Board, Alton, Ill.
R. S. Hunter, Hunter Associates Lab., McLean, Va.
F. C. Schmutz, New Jersey Zinc Co., Palmerton, Pa.
L. C. Aldrich, West Virginia Pulp & Paper Co., Covington, Va.
D. R. Cushman, Socony Mobil Co.
J. R. Gunning, Abitibi Pulp & Paper Co., Georgetown, Ont.
B. Q. Haynes, B. F. Perkins & Son, Holyoke, Mass.
L. J. Slentz, Solvay Process Div., Syracuse, N. Y.
M. P. Boland, Columbia-Southern Chem. Corp., Barberton, Ohio
L. M. Tyler, Howard Paper Mills Inc., Dayton, Ohio

The meeting opened with the appointment of D. Noel Obenshain as temporary meeting chairman to preside for the purpose of electing committee officers for the following year.

The following slate of officers were nominated and elected for a period of one year.

Chairman—J. R. Gunning
Vice-Chairman—L. J. Slentz
Secretary—B. Q. Haynes

The newly elected chairman then assumed the chair from Mr. Ogenshain and called upon James d'A. Clark for a few words.

Mr. Clark offered a few suggestions in regard to obtaining new R. C. Methods. He suggested a review of past papers, published over a period of years, in which usable methods had been described. He further suggested that R. C. Methods, when written, be submitted directly to TAPPI for rewrite by any individual who, in their opinion, is qualified to do so. The procedure could be sent to the individual accompanied by a copy of the approved format for guidance in rewriting. He stressed the importance of simplification in methods writing in order to expedite getting the methods printed and in the hands of TAPPI mmbers where they

could be used. Once in use, revisions could be made later based upon comments received from the field.

Chairman Gunning thanked Mr. Clark for his suggestions and stated that they would be considered in drawing up a simplified procedure in processing R. C. Methods.

The meeting was adjourned at 1:59 p.m.

October 2, 1958

The third session of the R. C. Methods Committee was held at 9:45 a.m. on Oct. 2, 1958, in the Wilmington Room. The following committee and TAPPI members attended:

M. P. Boland, L. C. Aldrich, F. A. Delforge, J. R. Gunning, L. J. Slentz, B. Q. Haynes, J. W. Eastes, Scott Paper Co., Chester, Pa., J. M. d'A. Clark, A. J. Winchester.

Chairman Gunning read a letter from P. S. Cade requesting that he be relieved as chairman of the Supplier Liaison Subcommittee because of the pressure of other business. After a discussion relative to obtaining a successor to Mr. Cade, it was suggested that Mr. Cade be requested to retain the chairmanship until a new chairman could be announced at the February meeting.

Chairman Gunning then announced new appointments to the various subcommittee and submitted the following roster of subcommittee for the ensuing year:

Review and Revision

C. L. Stumpp, *Chairman*
L. C. Aldrich
C. L. Hess
R. S. Hunter
J. F. Theriault

Supplier Liaison

P. S. Cade, *Chairman*
M. P. Boland
L. C. Aldrich
R. D. Faunce
J. J. Forsythe
H. J. Connell
F. C. Schmutz
C. E. Price
Frank Cassna

Instruments and Equipment Liaison

Clyde Eckhart, *Chairman*
Ed Benz
D. R. Cushman
Anthony Bellucci
D. J. MacLaurin
W. L. Cassiday

Other Organizations Liaison

W. F. Bachelder, *Chairman*

Editorial Board

L. J. Slentz, *Chairman*
Members, entire group

Organization Committee

Leon Tyler, *Chairman*
K. R. Martin
J. P. Carey, Jr.

The method of processing R. C. methods was then reviewed and discussed. It was pointed out that past experience indicated that the current system was too complicated and time consuming. Jack Winchester suggested that the methods be sent to TAPPI, as received, and sent out for rewrite as suggested in J. d'A. Clark's remarks at the previous session. Once written, they could be published in the TAPPI magazine as a suggested R. C. method. Comments on its use would be invited from the field. After a prescribed time, they could then be reviewed by the Review and Revision Committee and submitted for publication and distribution as an R. C. method.

Chairman Gunning offered to submit a new processing procedure based upon the comments and suggestions made during the discussion. The procedure would be distributed to the committee members previous to the February meeting at which time action would be taken on its adoption.

The meeting was adjourned at 11:30 a.m.

B. Q. Haynes, *Secretary*

Plastics Laminates Committee

A meeting of the Plastics Laminates Committee was held at 9:00 a.m., Oct. 20, 1958, at the Sheraton-Kimball Hotel in Springfield, Mass.

This meeting coincided with the beginning of the 13th Annual Plastics-Paper Conference held at this same location. The following members and guests were present:

R. B. Herring, Eastman Chemical Products
Raymond G. Reynolds, Underwood Corp.
L. P. Gause, Buckeye Cellulose
William J. White, Mosinee Paper Mills
Harold Rendleman, The Richardson Co.
Frank Towsley, The Dow Chemical Co.
George P. Colgan, Air Reduction Co.
Thomas Raphael, Arthur D. Little, Inc.
S. D. Hellberg, Union-Camp Paper Co.
C. J. Seiler, Behr-Manning
Clark Miller, Pauelyte Div., St. Regis Paper Co.
O. F. Ecklund, American Can Co.
D. Frank Kelsey, American Can Co.
B. R. Whaley, Sonoco Products Co.
C. Elmer, Monsanto Chemical Co.
James M. Farnum, Hurlbut Paper Co.
Stanley J. Batruk, Jr., New Jersey Zinc Co.
R. H. Doughty, Fitchburg Paper Co.
M. H. Kollen, Fabricon Products
R. M. Drummond, International Paper Co.
M. W. Zembal, Dow Chemical Co.
J. J. Forsythe, International Paper Co.
D. M. Gilmore, Brown Co.
H. A. Spencer, Knowlton Brothers
J. F. Blais, Chemical consultant
R. C. Brown, U. S. Envelope Co.
E. T. Bailey, International Paper Co.
R. C. Chavron, U. S. Envelope Co.
L. E. Loessi, Latex Fiber Industries
D. H. Bond, Owens-Illinois Glass Co.
S. E. Church, Rayonier, Inc.
S. M. Bazler, General Electric Corp.
W. E. Morris, Allied Chemical Corp.

1. It was announced that the 1959, 14th Annual Plastics-Paper Conference, would be held at the Edgewater Beach Hotel, Chicago, Ill. W. R. Zwecker offered to assist the conference committee on the 1959 Chicago arrangements.

2. A motion was carried to adopt membership rules similar to those in force in the Coating Committee. A statement of the rules and an application form for Committee membership, will be sent to the current membership list. The 1959 Plastics Laminates Committee membership list will be composed of those people completing this form.

3. A discussion followed of proposed additional resin-paper tests which the committee might undertake. Uniformity of impregnation, resin solids in paper and stiffness of impregnated sheet were suggested. It is planned to initiate committee work on some of those suggested.

4. An election of committee officers for 1959 was held and the following individuals designated:

H. A. Spencer, Knowlton Brothers, *Chairman*
C. J. Seiler, Behr-Manning, *Vice-Chairman*
W. E. Morris, Allied Chemical Corp., *Secretary*

5. A report on the results to date on the statistically designed resin penetration test was presented by D. Gilmore, Brown Co. Ten of the 11 participating laboratories have submitted their data. No final conclusions will be available until the data are complete and analyzed. However, the following observations were made based on the available data: (a) On both the kraft and alpha sheets a difference appeared to exist among laboratories and among test fluids as to time of initial penetration. However, agreement appears considerably better at the 99% penetration level.

(b) The data appear to show differences among papers. Several months will be required to analyze the data. It is planned to prepare a paper on these results for presentation at the 14th Plastics-Paper Conference.

W. E. Morris, *Secretary*

Meeting of Fluid Mechanics Committee

The Fluid Mechanics Committee, Engineering Division, met at the Hotel Multnomah, Portland, Ore., Wednesday, July 30, 1958, at 12:00 noon, with Nicholas Shoumatoff, chairman, presiding.

The minutes of previous meeting of the full Fluid Mechanics Committee on Feb. 19, 1958, were read and adopted.

The following members were present:

N. M. Reitzel, Rice Barton Corp.
J. D. Lyall, Armstrong Cork Co.
H. D. Fisher, Ontario Paper Co.
N. A. Ednie, E. I. du Pont de Nemours & Co.
W. L. Ingmanson, Institute of Paper Chemistry
K. J. Mackenzie, Eastman Kodak Co.
N. Shoumatoff, West Virginia Pulp & Paper Co.
J. A. Smith, Clark & Vicario Corp.

Present also were the following guests, including those acting in place of absent members:

J. D. Maloney, Mead Corp.
Gleb Goumeniouk, Consultant, West Vancouver
J. W. Riese, Kimberly-Clark Corp.
A. A. Robertson, Pulp & Paper Research Institute, Montreal
J. W. Daily, Massachusetts Institute of Technology
M. N. Davis, Kimberly-Clark Corp.
O. R. Witworth, Black-Clawson Co.

The first subject discussed was the possible survey of fluid mechanics applications in the pulp and papermaking process. (This was first developed at an informal luncheon meeting previously on Tuesday which was attended by nine committee members and guests.) This survey would include a comprehensive review of the state of the art of fluid mechanics including unsolved problems at each phase of the pulp and papermaking process. It was suggested that a questionnaire be made up and issued to members for their recommendations and suggestions as to possible topics which would fall into the category of such applications. A possible tie-in of these topics with previously published TAPPI project lists was suggested by Dr. Davis. Mr. Lyall mentioned also a possible correlation of these topics with the TAPPI data sheets system.

The matter of having a separate subcommittee for this project was discussed and it was decided that best results might come from active participation by all committee members rather than by a subcommittee.

Further items discussed included how the information should be obtained, how compiled, and how issued. As to the latter, it was felt that the project might be sufficient in scope to constitute a TAPPI monograph for publication. The committee indicated its general approval of the idea of this project and the chairman was authorized to proceed with preliminary planning and setting up an outline for this study.

The next discussion related to the two current committee-sponsored research programs at the Massachusetts Institute of Technology and the University of Michigan relating, respectively, to the study of flow characteristics of dilute fiber suspension and the instability of stock on the fourdrinier wire.

It was recalled that a grant of $16,500 had recently been approved by the Research Appropriations Committee for continuing the work at M.I.T. under Project No. 147. J. W. Daily gave an impressive talk in the general sessions covering a final report of the work accomplished under TAPPI Projects Nos. 93 and 126.

Dr. Yih of the University of Michigan presented a very complete and comprehensive progress report covering the experimental and theoretical investigations at the University of Michigan conducted under Project No. 140.

Mr. Mackenzie reported that the Hydraulics Committee had completed its sponsored program at the University of Maine on friction loss of paper stock. Results of this very successful research program were summarized in an excellent motion picture shown at the general sessions. The Hydraulics Committee is now dissolved as a separate committee and has become a subcommittee of the Fluid Mechanics Committee. It will continue its functions in the general field as previously with Mr. Mackenzie as chairman. It is expected that the subcommittee will follow up in the collection of final results with the new shear tester and in various thesis work using the existing flow loop at the University of Maine.

In addition the following projects were discussed as a possibility for future investigation:

1. Study of flow through porous media, including drainage on wire, dewatering in press section, and filtration on continuous washers.
2. Study of high shear flow, especially as related to refining.
3. Study of two-phase liquid gas flow, especially as affecting paper stock behavior in fields (1) and (2) above.

The question of establishing separate subcommittee for each of these studies was discussed and it was concluded that this might be deferred pending a more complete analysis of the scope of the fluid mechanics application in the pulp and papermaking process.

It was agreed that a review would be made of the pertinent TAPPI data sheets falling within the jurisdiction of fluid mechanics committee under the direction of the vice-chairman, Mr. Lee.

The subject of technical papers for presentation at the 14th Engineering Conference at Pittsburgh in October, 1959, was then brought up. From this discussion it appeared that more papers would be available than could be properly presented at Pittsburgh in the normal time allocated for our sessions. Accordingly it was decided that a Fluid Mechanics Committee program would be presented at the annual TAPPI meeting in New York in February, 1959.

Papers suggested by members resulted in setting up the following tentative program for annual meeting in New York:

1. "Instability of Flow on the Fourdrinier Wire—Report of TAPPI Project No. 140," by C. S. Yih and A. C. Spengos, University of Michigan.
2. "Internal Pressure Distributions in Compressible Mats Under Fluid Stress," by W. L. Ingmanson, The Institute of Paper Chemistry.
3. "The Friction of Paper Stock in Pipes—Summary of TAPPI Research at the University of Maine," by K. J. Mackenzie, Eastman Kodak Co. (Mr. Mackenzie will also show a color motion picture film.)
4. "Secondary Flow Phenomena in Nonlinear Fluids," by J. L. Ericksen of Johns Hopkins University.
5. "Secondary Motions in Flow Between Concentric Rotating Cylinders," by David W. Appel, University of Kansas.

For the 14th Engineering Conference Meeting at Pittsburgh the following papers were suggested:

1. "Characteristics of Flow of Dilute Fiber Suspension—Report covering investigations under TAPPI Project No. 126," by A. T. Ippen and W. J. Daily.
2. "Instability of Paper Machine Approach Flow with Exceptional Wall Smoothness," by H. T. Fisher, Ontario Paper Co.
3. "Wet End Process for Handling Synthetic Fibers," by N. A. Ednie, E. I. du Pont de Nemours & Co.

The meeting adjourned at 1:50 p.m.

J. A. Smith, *Secretary*

Container Testing Committee

The meeting of the Container Testing Committee was called to order by the chairman, M. J. Clark, at 2:20 p.m., Nov. 4, 1958, at Cincinnati, Ohio. The following members were present:

M. J. Clark, *Chairman,* Inland Container Corp.
G. C. Lecky, *Secretary,* F. J. Kress Box Co.
W. J. Balster, The Don L. Quinn Co.
H. B. Johnson, International Paper Co., Container Div.
Earl Knapp, West Virginia Pulp and Paper Co., Hinde & Dauch Div.
W. B. Lincoln, Jr., Inland Container Corp.
C. S. Macnair, Acme Steel Co.
K. R. Martin, Olin Mathieson Chemical Corp.
W. S. McDonald, International Paper Co., Container Div.
H. G. Nelson, Owens-Illinois Glass Co.
H. J. Ostrowski, Hinde & Dauch Paper Co.
H. W. Seibel, Gaylord Container Corp.
R. E. Swingle, Acme Steel Co.
C. J. Zusi, Packaging Consultant

Flat Crush Subcommittee

The subcommittee chairman, Mr. Nelson, reported that he had mailed to the committee members copies of the Container Testing Laboratory report on the work they had done on the two flat crush machines together with a questionnaire dealing with the question of testing a third machine.

The results of this questionnaire were: 19 replies received; 15 voted to complete the test work with another machine, and four voted not to do any more testing. The machines suggested were the Mullen and Baldwin Southwark Testers. Also Container Corp. offered to make tests at no cost to the committee on a machine they were in the process of developing. It turns out, however, that Perkins & Co. are in no position at the present time to furnish a modified Mullen for the test and it is impractical to use the Baldwin Southwark. It was therefore voted that Mr. Nelson write Container Testing Laboratories to forget the third machine and that samples be sent to George Maltenfort at Container Corp. for testing on his machine. Container Testing Laboratories was also to be instructed to finish the statistical analysis of the tests run on the two machines as soon as possible.

Mr. Nelson also reported that he had appointed a committee of three headed by Hugh Johnson to begin writing up a new flat crush test method. It was the thinking of this committee that the present ASTM Standard Method for Flat Crush of Corrugated Board D-1225-54 could be used as a basis with very few changes, namely, a change of the loading rate, and some changes in the reporting procedure. It was voted that we wait for the final statistical analysis of the Container Laboratory test results and at the February meeting appoint a task force to rewrite the flat crush procedure following the ASTM formula with changes suggested at that time.

Mullen Subcommittee

As Mr. Grundy, the Mullen Subcommittee chairman, was not able to be present, Mr. Knapp spoke for the subcommittee. He suggested that in order to get a start on a Mullen test procedure, we first should write up a procedure for paperboard only and forget corrugated board for now. Before we do this, however, we should have the scope of the existing TAPPI Standard T 403 m-53 limited to paper only and not to paperboard testing. The secretary was instructed to write the Paper Testing Committee and suggest that the scope of the TAPPI Standard T 403 m-53 was too broad and ask them to consider changing the scope of that procedure to encompass only paper products. The chairman was also instructed to appoint a small task force to finish writing a Mullen test procedure for paperboard only and submit it to the committee in February.

The chairman read a letter from Mr. Haynes of Perkins & Co. relative to Mullen tester diaphragms. Extracts from this letter are attached to the minutes and the chairman, Mr. Clark, would appreciate comments from members of the committee so that he can intelligently formulate some answers to the questions asked by Mr. Haynes relative to diaphragm manufacture.

It was, however, the feeling of the committee members present that we should not concern ourselves with the diaphragm specifications. The only thing we are concerned with is that the diaphragm has the correct distention at the required pressures.

Compression Subcommittee

Mr. Martin reported his committee was in the process of rewriting the compression test as directed in the last meeting and would recirculate it with the changes to the full committee for comments.

The question of adapting the ASTM drop test to the TAPPI form and adopting it as a standard will be circulated for letter ballot.

ASTM is now working on a Conbur test procedure which will be studied upon its completion to see if it could be used as a TAPPI Standard.

The committee voted to agree to the dissolution of the joint ASTM-TAPPI Committee on Shipping Containers, and the secretary was instructed to send the necessary letters.

The next committee meeting will be in conjunction with the TAPPI Annual Meeting in New York, Feb. 23–26, 1959.

It was agreed by all present that the Container Testing Committee would continue to meet with the Corrugated Container Conference at the fall meeting.

G. C. Lecky, *Secretary*

Fillers and Pigments Testing Committee

A meeting of the Fillers and Pigments Testing Committee was held on Sept. 30, 1958, at Savannah, Ga., with the following persons present:

P. W. Bartholomew, Minnesota & Ontario Paper Co.
M. P. Boland, Columbia-Southern Chemical Corp.
V. Brecht, Central Fibre Products Co.
H. C. Brill, E. I. du Pont de Nemours & Co., Inc.
J. Cella, Lowe Paper Co.
A. W. Claxton, Minerals & Chemicals Corp.
R. Drexel, Southern Clays Inc.
E. B. Frost, Southern Clays Inc.
G. E. Hall, Jr., Wyandotte Chemicals Corp.
H. Kranich, Johns Manville Products Corp.
W. H. Kreiling, Lowe Paper Co.
R. J. La Fond, St. Regis Paper Co.
L. Melshimer, American Cyanamid Co.
W. Neuss, Stein Hall & Co.
P. W. Plante, St. Regis Paper Co.
F. C. Schmutz, New Jersey Zinc Co.
P. Sennett, Southern Clays Inc.
M. F. Warner, Sierra Talc & Clay Co.
J. B. Whitley, J. M. Huber Corp.
W. R. Willets, Titanium Pigment Corp.
J. A. Winchester, TAPPI

The first formal meeting was called to order at about 2:00 p.m. by Mr. Willets, the chairman, with 20 members and visitors present. In the absence of Mr. Batruk, secretary, Mr. Schmutz recorded the meeting. The meeting followed the agenda proposed with the letter of August 12 to the committee membership.

Item 4 in this agenda was taken up first, namely, the appointment of members of this committee to the Joint Task Group of ASTM Committee D6. The ASTM group is to develop a quantitative method for mineral fillers and coating constituents of paper, but there has been some question whether such a method falls within the jurisdiction of the TAPPI Fillers and Pigments Committee. It was decided that the proposed ASTM activity was not a responsibility of this committee. K. H. Williams, vice-chairman of the Testing Division, next designated the following methods as

coming specifically within the jurisdiction of the Fillers and Pigments Committee:

Chemical	T 421-615-627-645-651
Physical	T 647-648-649
Optical	T 646
Microscopical	T 488

Reports were presented covering the projects assigned to the different committee men. They were as follows:

No. 699 Method for Calcium Carbonate—George Hall

A draft of a method is not yet ready for presentation. Because of the many forms of calcium carbonate used by the paper industry, there is some difficulty in making the method broad enough. It was suggested that the method be built around a most widely used type. Where recognized methods of test do not apply, it may be necessary to consider methods now in use in individual laboratories which are based on experience.

No. 700 Method for Talc—Maurice Warner

The preparation of the draft for this method is underway. It was proposed that the method include a procedure for distinguishing between talc (magnesium silicate) and tremolite (calcium magnesium silicate), also cover talc and talc-like materials. Another suggestion was that the product specification should be tied in with the end use. There also may have to be a distinction between eastern and western talcs.

No. 701 Diatomaceous Earth—Herbert Kranich (replacing Wayne Dowst)

Many of the established TAPPI methods, as oil absorption and wet bulk density do not apply to diatomaceous silica. On the other hand, a property as wet bulk density is important. A method is being drawn up for committee approval which is built around methods now in use by the producers of this product. The limits included in this method will have to be rather broad and general.

No. 702 Calcium Silicates—Herbert Kranich (replacing Wayne Dowst)

It was suggested by Mr. Kranich that the committee delay action on this method. This position was also advised by other present.

No. 704 Methods for Slurry Viscosity, Enzyme Compatibility, Adhesive Demands, etc.—Paul Plante

The chairman suggested that the items in this heading be considered separately. Among the factors affecting slurry viscosity, the following were discussed: type and per cent of dispersants, pigment concentration, water hardness, and methods for running the viscosity determination. No definite action was taken.

It was suggested that work on enzyme compatibility and adhesive demand be postponed until the work on the determination of slurry viscosity has been completed.

No. 705 Correlation of Test Methods for Various White Fillers and Pigments—William Kreiling

A written report was presented by Mr. Kreiling covering work on this assignment. The discussion of this report developed the following comments:

1. Sampling—There is a need for an all-over method.
2. Specific Gravity—No special work is needed.
3. Tinting Strength—A method should be developed.
4. Particle Size Distribution of Coating Clays—The Anderson pipet as now used by the clay industry should be considered. The turbidimetric procedure of Musgrave and Harner should receive consideration. Reprints of this method as published in the *Journal of the American Ceramic Society,* 37 No.(8): 386–390 (1954) were distributed. The chairman called attention to the fact that the ASTM has held a symposium on this subject and that it may be desirable to delay final action by this committee until the information is published.
5. Gross Particle Size—Mr. Whitley agreed to report back on this subject.
6. Hiding Power—The question was raised as to the applicability of ASTM methods to paper. Mr. Melsheimer agreed to prepare a draft of a method which will be specifically for use in connection with paper.

New Business

A consideration of methods of tests for colored pigments was suggested. Mr. Brill was assigned the task of investigating this proposal, particularly from the viewpoint of whether this activity comes within the jurisdiction of this committee.

A commentary on the Musgrave and Harner method for particle size distribution will be prepared by Mr. Warner.

The meeting of the committee was completed with the last item and adjourned.

F. C. Schmutz, *Secretary Pro tem.*

Alkaline Pulping Committee

The Alkaline Pulping Committee met at the Arlington Hotel in Hot Springs, Ark., on Sept. 23, 1958. The meeting was called to order at 2:00 p.m. by chairman Jack Limerick. Present for the meeting were:

K. Running, Halifax Paper Co., Roanoke Rapids, N. C.
M. B. Pineo, Brunswick Pulp and Paper Co., Brunswick, Ga.
D. O. Adams, West Virginia Pulp and Paper Co., Covington, Va.
P. H. West, Thilmany Pulp and Paper Co., Kaukauna, Wis.
H. O. Teeple, TAPPI, N. Y.
D. C. Gillespie, Dorr-Oliver, Inc., Stamford, Conn.
A. W. Pesch, International Paper Co., Mobile, Ala.
P. B. Borlew, Celulosa de Chihuahua, Chichuahua, Mexico
D. Wetherhorn, Southern Paperboard Corp., Post Wentworth, Ga.
V. Woodside, Olin Mathieson Chemical Corp., New Orleans, La.
V. F. Waters, Southern Pulp and Paper Manuf., Atlanta, Ga.
W. B. Stengle, Crossett Co., Crossett, Ark.
H. M. Owen, Gulf States Paper Corp., Tuscaloosa, Ala.
J. McK. Limerick, Bathurst Power and Paper Co., Montreal, P. Q., Can.

1. Minutes of the February meeting were discussed. M. B. Pineo moved the acceptances of the minutes as distributed and the motion carried.

H. O. Teeple suggested two copies of the minutes be sent to TAPPI headquarters; one for the file and one to work with. This was established as standard future practice. Tape recordings of the past two meetings of the committee; they will be filed with TAPPI headquarters.

2. Details of the Hot Springs conference were discussed by W. B. Stengle, Local Arrangements. Registration was set at $12.00 for members and $17.00 for nonmembers. There is to be registration for ladies as Sandy-Hill is sponsoring the ladies program.

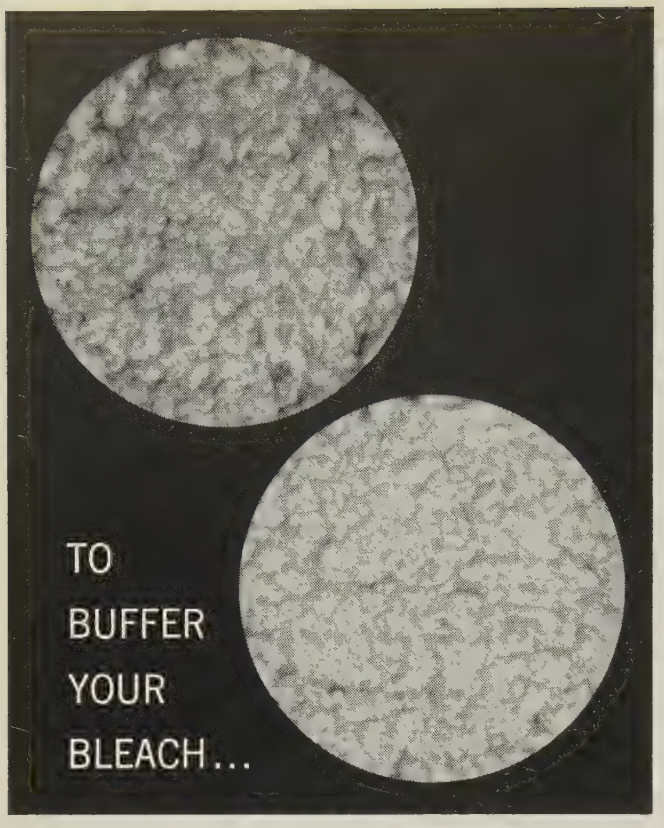
Chairman Limerick complimented the local arrangements committee on their work and the well organized meeting. Mill visits to Dierks and Camden are planned.

D. O. Adams reported on the program and asked A. W. Pesch to moderate the Wednesday afternoon meeting. Mr. Adams was complimented on the Alkaline pulping program.

3. The group asked the chairman to express the condolences of the committee to H. Y. Charbonnier, who was unable to attend due to the death of his father.

4. Plans for the annual meeting in February were discussed. Alkaline committee was set at 2:00 p.m. Sunday afternoon in a private meeting room at the Commodore. Considerable discussion was carried on concerning program and meeting of Alkaline Pulping in February.

A motion was made and carried five to four to have four papers (the best possible) in an afternoon session, if possible.



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B-W " "	1:1.60	19.50	31.2	1.676	70
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Suggestions were made to avoid conflict with other sessions having papers of a major interest to Alkaline Pulping.

5. A lengthy discussion of papers and the manner of presenting papers ensued. The general consensus was: (a) too many poor quality papers are being published. (b) papers should not be read in their entirety. (c) there was a feeling discussion should be recorded and published. (d) most people liked the idea of preprints such as are used in Canada, and (e) there was some feeling that some papers given might not be published.

H. O. Teeple explained TAPPI plans for improved quality of papers. Apparently these plans should help this situation.

6. The question of officers for 1959 was raised by K. D. Running as he did not wish to serve as chairman in 1960. After considerable discussion a motion was made and passed setting up a nominating committee composed of M. B. Pineo, P. A. West, and D. Wetherhorn to suggest a vice-chairman for 1959. Other officers to remain the same until 1960. K. D. Running is program chairman for fall meeting of 1959.

7. The matter of having a fall meeting in an area other than in the South raised some arguments and doubts. It was pointed out the Alkaline Pulping Committee is not only national but international in interest and make-up and should meet elsewhere in some ratio of interest. At least one meeting in 10 was suggested. A motion was made to hold the meeting on the West Coast in 1960. The motion carried eight to four.

General considerations for the meeting were: (1) committee meeting to be on Sunday, (2) general meeting to be Monday and Tuesday, (3) mill visits Wednesday, Thursday, Friday, (4) suggested date Aug. 21, 1960, (5) location Portland, (6) chairman to contact West Coast group and obtain their support.

8. Some time was spent on the Jacksonville meeting. Suggestions were made for local arrangements committee set up. The chairman will contact people in the area to set up local arrangements.

9. Action was taken on the resignation of N. May from the committee and his suggestion of D. J. Maclaurin to replace him. Motion was made and carried to ask Mr. Maclaurin to be a member of the committee.

10. D. Wetherhorn reported for the Testing Subcommittee composed of Messrs. Kessler, Borlew, Stevens, and Wetherhorn. The main project is the methods of analysis of white and green liquor. A research project on this problem could not be obtained. Apparently, this project is also shown as being under the nonfibrous testing committee. Mr. Teeple agreed to look into the matter and revise the record. Questions were asked regarding the Pascoe-Borlew method. According to the record this method was voted as alternate method by the Alkaline Pulping Committee at the February meeting and referred to TAPPI H. Q. Mr. Teeple agreed to check on the status of the method.

A. W. Pesch brought up the so-called activity factor of liquor and raised the need for having a method of analysis recognized by TAPPI in this area. D. Wetherhorn mentioned the method in use at Southern Paperboard. Mr. Wetherhorn will take the matter up with the subcommittee.

11. P. B. Borlew reported on the corrosion subcommittee work. At the moment they are watching the literature and keeping track of the activities in this field.

12. Projects: D. Gillespie's suggestion for a monograph on chemical recovery was discussed together with the outline he prepared. A motion was made and passed establishing a committee of Messrs. Gillespie, Pesch, and West to investigate the matter and make a recommendation to Alkaline Pulping.

Mr. Pineo brought up the matter of having a fall meeting of the Pulping Division instead of just Alkaline Pulping. The meeting to be known as the Pulping Division Conference. After some discussion this matter was tabled for the February meeting.

ROBERT R. FULLER, *Secretary*

Current Status of Alkaline Digester Corrosion As Reported by Regional Digester Group

H. M. CANAVAN

THE regional program of collecting digester data in simplified form was started in February, 1955. The program is based upon the use of the TAPPI Monograph on "Inspection of Digesters." All data for an individual digester are collected on a single-page form entitled, "Mill Report Form." These forms are collected periodically by the 11 regional representatives appointed from the committee mill membership on a geographical basis. The information obtained is tabulated to obtain a periodic index of the current status of the digester corrosion problem.

In preparation of this third report covering regional digester activity, TAPPI mill report forms from 30 mills covering 229 digesters were examined. The reports received from four mills could not be used due either to lack of sufficient information or because the thickness measurements were the first that had been taken and no corrosion rate could be established.

Reports from 26 mills were used in preparing this report which includes 229 carbon steel, stainless steel and inconel, lined or clad, digesters. Reports were received covering 192 carbon steel digesters, but it was necessary to omit several of the digesters from the study due to lack of complete information. Reports were received covering 24 stainless steel and inconel lined or clad digesters. The corrosion rates found in the current data correspond closely with those reported in previous studies.

Table I shows the average current corrosion rate and average corrosion rate in the critical area of carbon steel digesters for individual mills.

Tables II and III provide the same information for inconel and stainless steel lined or clad digesters.

The supporting corrosion data contained in questions 14 through 27, inclusive, of the mill report form were summarized as follows:

Question 14: Location of critical area?

	Upper shell, %	*Middle shell, %*	*Lower shell, %*	*Top head, %*	*Bottom head, %*	*No critical area, %*
1957	23.4	37.3	18.9	5.0	9.4	6.0
1956	36.5	40.9	7.6	2.5	3.1	9.4
1955	23.9	53.1	5.2	9.5	2.3	...

Question 15: Has critical area moved since last inspection?

	Yes, %	*No, %*
1957	20.7	79.3
1956	22.8	77.2
1955	14.8	85.2

Question 18: Method of estimation used:
Numerical—18 mills or 74.4% Graphical—8 mills or 25.6%

Question 19: Has the average current corrosion rate changed since last inspection?

	Decreased, %	*Increased, %*	*No change, %*	*Don't know, %*
1957	40.7	17.5	21.7	20.1
1956	33.1	31.8	26.3	8.8
1955	26.7	44.6	13.9	14.8

Question 21: Has the current corrosion rate at the critical area changed since last inspection?

	Decreased, %	*Increased, %*	*No change, %*	*Don't know, %*
1957	36.5	26.6	18.2	18.7
1956	37.2	34.4	22.3	6.1
1955	30.4	39.3	15.7	14.6

Question 23: Is a current change in general corrosion indicated by visual inspection only?

	Decreased, %	*Increased, %*	*No change, %*	*Don't know, %*
1957	5.3	7.9	76.3	10.5
1956	7.3	12.6	72.2	7.9
1955	10.1	10.1	63.6	16.2

Question 24: Is a current change in localized attack indicated by visual inspection only?

	Decreased, %	*Increased, %*	*No change, %*	*Don't know, %*
1957	4.5	12.5	73.0	10.0
1956	10.6	8.6	74.8	6.0
1955	4.0	7.1	75.8	13.1

Question 26: Location of unscaled areas.

	Top head, %	*Upper shell, %*	*Middle shell, %*	*Lower shell, %*	*Bottom head, %*
1957	19.8	18.1	24.0	18.5	19.6
1956	23.4	21.8	20.5	11.2	23.1
1955	21.2	18.9	22.7	17.3	19.9

Question 27: Changes made since last inspection which might affect corrosion rate.
Ten (10) mills reported changes affecting 39 digesters.

The cause of corrosion in the critical area was summarized as follows:

Table I. Current Corrosion Rates for Digesters—Carbon Steel

Mill code	*Number of digesters*	*Mill average corrosion rate, mils/yr.*	*Mill average corrosion rate critical area, mils/yr.*
A	10	8.1	20.4
B	2	24.0	44.5
C	10	16.3	36.4
D	5	50.0	80.0
E	11	52.5	76.3
F	6	52.3	41.8
G	4	30.0	94.8
H	5	[a]	136.0
I	6	31.8	65.0
J	3	5.6	13.0
K	4	61.0	80.0
K1	6	7.3	17.9
L	3	105.3	196.7
M	5	91.0	115.6
N	23	32.5	82.8
O	5	43.8	59.2
P	9	14.4	29.9
Q	15	7.6	44.1
Q1	4	31.3	45.5
R	8	9.5	108.8
R1	11	22.7	35.6
S	1	15.0	80.0
U	2	30.0	[a]
V	7	40.0	50.9
W	9	49.2	97.9
X	2	43.0	43.0
Z	6	3.6	5.4
Total	182		
Weighted average		30.4	62.6
Median		21.5	53.0

[a] Thickness measurement omitted from report.

H. M. CANAVAN, Chief Inspector-Boiler Div., Mutual Boiler and Machinery Insurance Co., Waltham 54, Mass.

Table II. Current Corrosion Rates for Digesters—Inconel Lined or Clad

Mill code	*Number of digesters*	*Mill average corrosion rate, mils/yr.*	*Mill average corrosion rate critical area, mils/yr.*
N	4	11.5	0.0
T	6	[a]	[a]
Total	10		
Weighted average		11.5	0.0
Median		3.0	0.0

[a] Thickness measurement omitted from report.

	1957, %	*1956, %*
Liquor charging	23.9	30.1
Liquor circulating	15.3	15.5
Normal corrosion	9.4	10.3
Chip impingement	10.2	8.2
Chip contour	3.9	7.3
All other causes	6.3	11.8
Don't know	31.0	16.8

The average current corrosion rate for 182 carbon steel digesters ranged from 0 to 179 mils per yr. with a median of 21.5 mils per yr. as compared with 28 mils per yr. in 1956. The average corrosion rate in the critical area ranged from 0 to 326 mils per yr. with a median of 53 mils per yr.

Reports were reviewed covering 10 inconel lined or clad digesters, but due to lack of information it was only possible to establish corrosion rates on four digesters. The average corrosion rate averaged from 0 to 40 mils per yr. with a weighted average of 11.5 mils per yr. and a median of 3 mils per yr. Reports were studied covering 14 stainless steel lined or clad digesters, but the corrosion rates had to be based on eight digesters due to insufficient information. The average current corrosion rate ranged from 0 to 29 mils with a weighted average of 8.5 mils and a median of 5 mils.

Table III. Current Corrosion Rates for Digesters—Stainless Steel 316 and 347 Lined or Clad

Mill code	*Number of digesters*	*Mill average corrosion rate mils/yr.*	*Mill average corrosion rate critical area, mils/yr.*
N	1	20.0	10.0
O	1	29.0	38.0
S	6	3.0	10.0
T	3	[a]	[a]
Y	3	[a]	[a]
Total	14		
Weighted average		8.5	13.5
Median		5.0	12.5

[a] Thickness measurement omitted from report.

The critical area in the carbon steel digesters was located in the middle shell in 37.3% of the digesters and in the upper shell in 23.4% of the digesters. This compares with 41 and 37% in the same areas in 1956. A greater number of mills reported the critical area to be in the lower shell than ever before. In 1956, 7.6% of the mills reported the critical area in the lower shell as compared with 18.9% in 1957. In 79.3% of the digesters the critical area has not moved as compared with 77.2% in 1956.

Table IV

		Audigage		*Vidigage*		*Differences*		
Chain	*Ring*	*Operator A*	*Operator B*	*Operator B*	*Operator C*	*A & B Aud.*	*B & C Vid.*	*B-Vid. B-Aud.*
1	2	1.32	1.33	1.35	1.35	0.010	0.000	0.020
1	4	1.26	1.29	1.28	1.29	0.030	0.010	0.010
1	8	1.22	1.22	1.22	1.23	0.000	0.010	0.000
2	3	1.33	1.33	1.31	1.34	0.000	0.030[a]	0.020
2	6	1.23	1.22	1.22	1.22	0.010	0.000	0.000
2	8	1.25	1.23	1.23	1.24	0.020	0.010	0.000
3	2	1.40	1.365	1.39	1.40	0.035	0.010	0.025
3	4	1.32	1.32	1.31	1.33	0.000	0.020	0.010
4	3	1.33	1.33	1.32	1.35	0.000	0.030[a]	0.010
4	4	1.29	1.25	1.27	1.28	0.040	0.010	0.020
4	6	1.22	1.25	1.22	1.22	0.030	0.000	0.030
4	8	1.25	1.25	1.27	1.28	0.000	0.010	0.020
5	2	1.415	1.415	1.41	1.40	0.000	0.010	0.005
5	4	1.32	1.33	1.33	1.33	0.010	0.000	0.000
5	8	1.26	1.26	1.25	1.22	0.000	0.030[a]	0.010
6	3	1.40	1.40	1.39	1.41	0.000	0.020	0.010
6	4	1.32	1.33	1.33	1.33	0.010	0.000	0.000
6	6	1.26	1.32	1.27	1.27	0.060[a]	0.000	0.050[a]
7	2	1.40	1.415	1.41	1.42	0.015	0.010	0.005
8	3	1.415	1.415	1.41	1.41	0.000	0.000	0.005
8	4	1.33	1.365	1.35	1.36	0.035	0.010	0.015
8	6	1.26	1.29	1.28	1.29	0.030	0.010	0.010
8	8	1.26	1.29	1.30	1.29	0.030	0.010	0.010
9	2	1.40	1.415	1.40	1.41	0.015	0.010	0.015
9	4	1.365	1.365	1.37	1.37	0.000	0.000	0.005
9	8	1.32	1.32	1.30	1.29	0.000	0.010	0.020
10	3	1.40	1.40	1.42	1.40	0.000	0.020	0.020
10	6	1.29	1.32	1.30	1.31	0.030	0.010	0.020
11	2	1.40	1.415	1.41	1.41	0.015	0.000	0.005
11	4	1.33	1.365	1.35	1.37	0.035	0.020	0.015
11	8	1.33	1.365	1.37	1.37	0.035	0.000	0.005
12	3	1.365	1.365	1.37	1.38	0.000	0.010	0.005
12	4	1.33	1.33	1.35	1.35	0.000	0.000	0.020
12	6	1.26	1.29	1.27	1.27	0.030	0.000	0.020
12	8	1.32	1.32	1.32	1.32	0.000	0.000	0.000
13	2	1.40	1.415	1.40	1.39	0.015	0.010	0.015
14	3	1.33	1.365	1.34	1.35	0.035	0.010	0.025
14	4	1.26	1.26	1.29	1.30	0.000	0.010	0.030
14	6	1.22	1.26	1.23	1.24	0.040	0.010	0.030
14	8	1.25	1.25	1.24	1.24	0.000	0.000	0.010
15	2	1.33	1.33	1.30	1.29	0.000	0.010	0.030
16	3	1.365	1.365	1.36	1.37	0.000	0.010	0.005
16	4	1.32	1.33	1.32	1.34	0.010	0.020	0.010
16	6	1.33	1.365	1.35	1.35	0.035	0.000	0.015
16	8	1.29	1.32	1.31	1.30	0.030	0.010	0.010

[a] Indicates greatest difference.

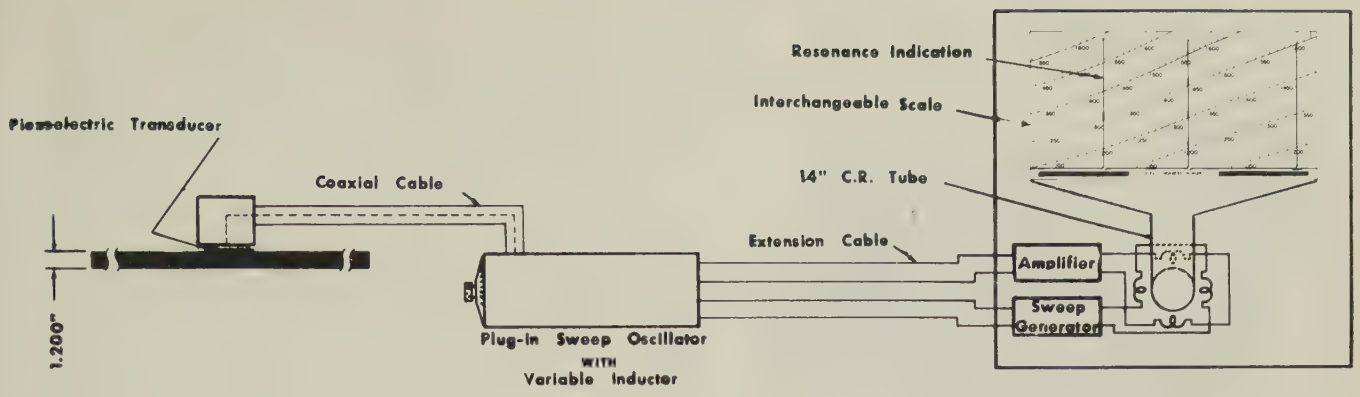


Fig. 1

Nine mills reported using stainless steel overlay in 25 digesters to retard corrosion and to extend the useful life of the digesters. This overlay welding was not only used to cover small areas in the critical area, but in some cases entire courses were covered. The results obtained by the use of this overlay protection appeared to be satisfactory. One mill reported using a stainless steel spray coating or metalizing and advised that after 2 years of operation it is gradually coming loose from the parent metal. One mill reported carbon steel overlay to retard corrosion in small areas and to provide a temporary means of extending the life of the digester. One mill reported using Nalco 161 with each cook, but after comparing the corrosion rate in this particular digester with others in the mill it did not appear to have much advantage.

Another mill reported using cathodic protection on six digesters and the results show that they have reduced their corrosion rate considerably. Several mills reported the use of baffles, deflectors, reducing liquor circulating time and the shifting of liquor nozzles, the results of which helped considerably to retard the corrosion in localized areas. In some instances, these changes caused the critical area to move from one section to another.

One hundred and thirty-one of the digesters reported are cooking pine chips, while the remaining 98 digesters are cooking hardwood or a mixture of hardwood and pine. Based entirely upon the information forwarded on the digester forms, there is little or no indication that the species of wood has any appreciable affect on the corrosion rate.

SUMMARY

The following conclusions are based on the data submitted:

1. The average current corrosion rate for carbon steel digesters based on the median has decreased from 28 mils to 21.5 mils per yr.

2. The average current corrosion rate in the critical area of carbon steel digesters based on the median has decreased from 60 mils to 53 mils per yr.

3. The critical area still appears to be confined to the middle shell, however, the percentage of the mills reporting the critical area in the lower shell has increased from 7.6 to 18.9%. This increase in percentage may possibly be due to the stainless steel overlay welding that is being done on the middle and upper shells.

4. It appears liquor charging is still leading the list of causes for corrosion in the critical area. However, a large number of mills reported that they do not know the cause of the corrosion in the critical area. It appears that if this percentage could be decreased we would have a better balance as to the cause of the corrosion in the questionable areas.

5. Mill representatives are providing more data and more accurate data than before. The operators are recognizing errors caused by the human element as well as the instrument. In most cases, these are corrected and reflected on the digester form. In a few cases, a negative corrosion rate was submitted.

6. Several additional mills are becoming interested in the program and some participated in this year's study. We appreciated receiving the reports, but as they were the first set of thickness measurements taken they could not be used because these studies are based on corrosion rates. Next year the corrosion rates can be established for these mills and used in this study.

7. It is interesting to note that the average corrosion rate for all carbon steel, stainless steel and inconel, lined and clad, digesters is 28.9 mils as compared with 8.8 mils for lined and clad digesters. The average corrosion rate for the critical area for all digesters is 58.9 mils as compared with 8.3 mils for lined and clad digesters. The average corrosion rate for carbon steel digesters versus lined and clad digesters based on the weighted average is 30.4 mils as compared with 8.8 mils.

Several mills which submitted reports on our present digester mill form for lined digesters were of the opinion that a separate form should be prepared to cover lined digesters. After reviewing the material submitted it appears that consideration should be given to preparing a form for use with different types of lined digesters as well as adding some questions covering the results of overlay welding.

The excellent response from the contributing mills and the cooperation and assistance received from the regional committee members are gratefully acknowledged.

As some of the insurance companies and mills participating in the program are determining thickness measurements using a Vidigage in conjunction with or in place of the Audigage, it was felt that it would be appropriate at this time to describe the operation of the Vidigage.

The basic operating principle of the automatic Vidigage thickness tester is identical with the operating principle of the Audigage thickness tester. The horizontal base line of the instrument represents a frequency sweep similar to the tuning range of the Audigage. Resonant frequencies are indicated by vertical deflections of the trace. Changes in thickness

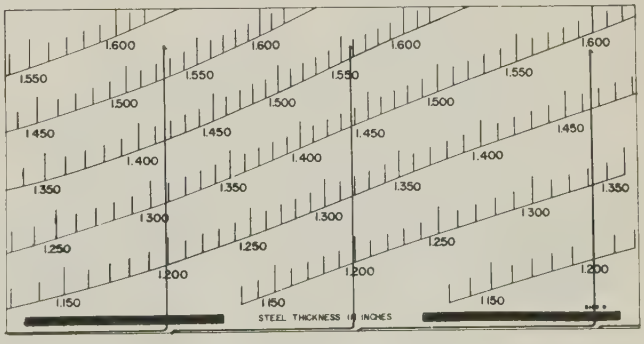
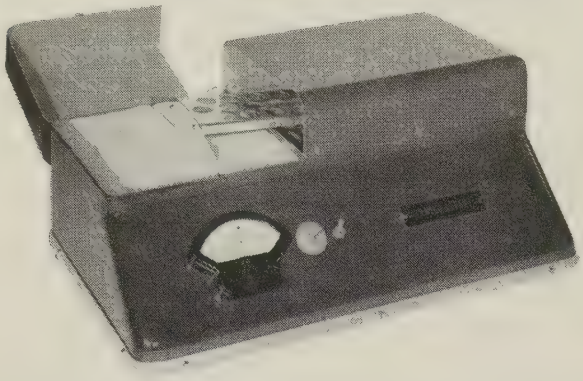


Fig. 2

THE HANDLE-O-METER

Is "handle" or "feel" a factor in your product?



If you make, convert, or finish tissue, non-woven textiles, and plastic film it is a factor.

Use the Handle-O-Meter to control processes. No training required. No human element. Results reproducible between operators and instruments. Tests completed in 15 seconds.

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influence the location of this trace and the spacing between multiple traces.

Plastic scales placed in front of the cathode ray tube enable the operator to read metal thickness instantaneously and directly. Typical scales used for digester inspection cover thickness ranges of 0.435 to 0.925, 0.660 to 1.175, 1.13 to 1.62 and 1.47 to 2.10 in.

The gage is shown schematically in Fig. 1. The dimensions of the basic instrument are $14^1/_2$ by $14^1/_2$ by 23 in., with a weight of 60 lb. The instrument can normally be used inside the digester. If desired, it can be left on the digester floor, since long extensions are available between the instrument and the small plug-in oscillator.

A typical direct-reading scale in shown in Fig. 2, with resonance indications for a metal thickness of 1.200 in. Three harmonic indications are shown; their location coincides with the 1.200 scale calibration on all harmonics. The scale actually covers a frequency range of 0.86 to 1.14 in. The actual resonant frequencies for the three harmonics are 0.88, 0.976, and 1.072 MC.

Thickness measurements reported in this paper were obtained with a scale having a direct-reading range of 0.435 to 0.925. Since the plate was too thick for this range, the operators obtained two intervals for each set of matching scale markings. The apparent thicknesses, read from the scale, were then doubled. This technique appeared to be satisfactory but probably resulted in an appreciable reduction in accuracy.

Approximately 3 years ago a comparison was made of thickness measurements taken by different operators and an Audigage to determine the human element and instrument error factor. The results were shown in TAPPI Monograph Series No. 12. It was decided to conduct a similar test using three operators, an Audigage, and a Vidigage.

Table IV shows the results of 180 readings taken with different operators and the two measuring instruments, namely, the Audigage and Vidigage.

Table V shows the average thickness at various rows and the variations in average thickness readings.

Table VI shows the average variations of all readings and by rows.

The maximum difference between any two Audigage readings taken at the same location was 0.060 in. This large a discrepancy occurred only once in 90 readings. The average error between the two sets of readings was approximately 0.015 in. The maximum difference between any two Vidigage readings taken at the same location was 0.030 in. This difference occurred three times in 90 readings. The average error between the two sets of readings was approximately 0.009 in. The maximum difference between any Audigage and Vidigage reading taken at the same location by the same operator was 0.050 in. This occurred once in 90 readings. The average difference between these two sets of readings was approximately 0.014 in.

It is felt that the results show good correlation between the techniques employed in this test. It might be pointed out that in arriving at the maximum differences shown, it was noticed that a single high reading on the Audigage was responsible for both large errors. This may be recognized by checking the readings at chain 6, ring 6, for both the Audigage and Vidigage. Obviously, the correct thickness is in the vicinity of 1.270 in. and the Audigage reading of 1.320 in. is incorrect. This is the only major discrepancy in 180 readings.

It is felt that greater accuracy is obtained by having one operator hold the crystal while another reads the instrument. This procedure, when used with the Audigage, allows the operator holding the instrument to view the hairline over the scale from a normal angle.

Presented at the Thirteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Portland, Ore., July 28–Aug. 1, 1958.

The author gratefully acknowledges the assistance received from the regional representatives, mill representatives, Branson Instruments, Inc., and the Laboratory Division of the Mutual Boiler and Machinery Insurance Co. in providing and developing material included in this paper.

Table VI

Audigage and vidigage operators	*Average variations* — *All readings*	*By rows*
Audigage A-Audigage B	0.015	0.012
Vidigage B-Vidigage C	0.009	0.005
Audigage B-Vidigage B	0.014	0.007

Table V

Ring No.	*No. of rdgs.*	*Average thickness at various rows* — *Aud. oper. A*	*Aud. oper. B*	*Vid. oper. B*	*Vid. oper. C*	*Variations in average thickness readings* — *Aud. opers. A & B*	*Vid. opers. B & C*	*Vid.-Aud. oper. B*
2	8	1.383	1.388	1.384	1.384	0.005	0.000	0.004
3	8	1.367	1.371	1.365	1.376	0.004	0.011	0.006
4	11	1.313	1.325	1.323	1.332	0.012	0.009	0.002
6	8	1.259	1.289	1.268	1.271	0.030	0.003	0.021
8	10	1.275	1.283	1.281	1.278	0.008	0.003	0.002

TAPPI STANDARDS

Testing Methods, Specifications and Recommended Practices

Weight-Volume Measurements of Pulpwood

Revision of Official Standard T 7 p-53
Reclassified as Tentative Standard T 7 m-58

(THIS STANDARD IS UNDER THE JURISDICTION OF THE FIBROUS RAW MATERIALS TESTING COMMITTEE)

In the following, methods are described for determining the quantity of pulpwood per unit of volume (a laboratory-racked cord). In addition, procedures are described for determining the ratio between 4-ft. and 8-ft. laboratory-racked cords, and the relation of racked cords to scaled cords.

DEFINITIONS

Racked cord is the piled volume of logs, with bark on, obtained by filling a rack of prescribed dimensions in a specified manner to equal 12 cu. ft.

Scaled cord is a unit volume of a pile of stacked logs, with bark on, obtained by dividing the over-all volume of the pile in cubic feet by 12.

Solid volume per cord refers to the solid cubic feet of wood exclusive of bark, in a cord of logs with their bark on.

Green wood usually is wood that is freshly cut. For the purpose of this method the term "green wood" is applied also to wood as received or as taken for test.

SECTION I. VOLUME OF LABORATORY-RACKED PULPWOOD

This may be determined by one of three methods, A, B, or C.

METHOD A

Apparatus

1. *Four-Foot Cord Rack.* A strongly braced rack 8.0 ft. long, with ends 4.0 ft. high (inside dimensions) and not less than 3 ft. wide; open at the top, front, and back. The front top corners of the ends have projections to carry a string stretched between the end members and level with their top surfaces at a distance of 6 to 8 in. in front of the rack.

2. *Platform Scale,* about 250 lb. capacity for weighing individual logs. Alternatively, one of 2 or 3 tons capacity for weighing a full cord.

3. *Saw.* A power-driven circular saw over 24 in. in diameter, is preferable.

4. *Hook Rule* of wood or metal with a metal hook at one end to form the zero stop.

5. *Steel Tape,* calibrated to read the average diameter or area of the cross section of a log from its circumferential measurement.

6. *Closed Containers,* for storing disks while testing; for example, two or more 10-gal., covered, garbage cans.

Test Sample

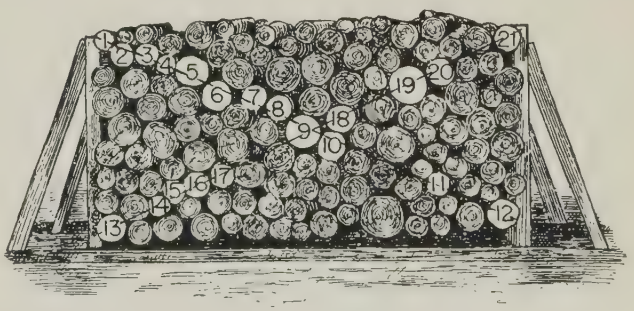
Select a representative sample of not less than 2 cords nor less than 0.1% of the total shipment. If removed from a large pile, special care is needed to ensure that the sample is representative.

Procedure

Unless the wood is in approximately 4-ft. lengths, measure and record the actual lengths of about 20 logs selected at random from the sample. If the wood is other than in 4-ft. lengths, cut a uniform length from each log so that the test specimens are approximately 4 ft. in length.

Rack the 4-ft. logs of wood into the laboratory cord rack, taking care that the logs are randomly selected and are neither too loosely nor too closely packed. When the rack is nearly filled, stretch a string between the projections at the top corners of the two end members of the rack, at the exact height of their top surfaces and 6 to 8 in. in front of them. Complete filling the rack, carefully placing the logs in the top layer so that the volume of wood in this layer above the string, approximately equals the volume of wood in this layer below the string.

Stretch the string diagonally across the face of the logs in the rack from the center of the log in an upper corner to the center of the log in the lower opposite corner of the rack. Beginning with the log in the upper corner,



Laboratory-Racked Pulpwood

* This method has been approved as a Tentative Standard by the Standards Committee. Criticisms are invited and should be sent to the Secretary, Tappi, 155 East 44th St., New York 17, N. Y. Minor changes may be made in this method before publication in loose-leaf form.

number and mark consecutively, each log whose center is within a distance from the string equal to the radius of the smallest log in the racked cord. Mark the logs across the other diagonal in the same manner. The logs so marked should number approximately 20% of the number of logs in the cord or at least 25. If not enough logs are thus marked, stretch the string across two other points on the face of the logs in the rack, for example horizontally or vertically across the middle of the rack and proceed with the numbering in the same manner as above.

If desired for future reference, a photograph of the racked cord of wood should be taken at this point. Figure 1 is a picture of a racked cord, showing part of the rack, the method of recording the log numbers, and the height to which the wood is filled into the rack. Shown superimposed upon this picture is shown the method of selection of the specimen logs, black lines representing the path of the string and logs numbered (1 to 21) by this procedure.

Obtain and record the net weight of the entire cord as soon as possible, weighing it either as a unit, or log by log, depending on the platform scale available, and separate the numbered specimen logs from the remainder of the cord. By means of the hook rule, determine the lengths of the specimen logs and record the figures to the nearest quarter inch.

Saw one knot-free disk of uniform thickness (between $^3/_4$ and 1 in.) from each of the specimen logs. From logs originally 4 ft. in length saw these disks at points 10 to 24 in. from either end; from those originally in 8-ft. or other lengths and from which shorter lengths have been cut, saw the disks from a section 5 to 24 in. from the freshly cut ends. Number the disks and place them in a closed container.

With each disk, proceed with the following steps as rapidly as accuracy allows, omitting (a), (b), and (c) for peeled wood:

(a) Remove a disk from the container and weigh and record the weight to the nearest 0.1 g.

(b) By means of the graduated steel tape, measure and record the average diameter.

(c) Remove the bark from the disk.

(d) Weigh the peeled disk and record the weight.

(e) Measure and record the diameter of the peeled disk.

If it is necessary to interrupt the performance of the foregoing steps, return the disk to the container until the testing is resumed. Store the disks in the same or another closed container prior to determining their density. Determine the average green- and dry-wood densities and the moisture content of the bark-free disks in accordance with TAPPI Standard T 18 m.

Calculations

From the data obtained on the sample disks, calculate and record, in addition to the specific gravity and moisture, the following:

(1) Average diameter (barked), to 0.1 in.

(2) Range of diameters (barked), maximum and minimum.

(3) Percentage of bark:

(a) By weight. Multiply by 100 the difference between the total weights of the disks before and after barking, divided by the total weights before barking.

(b) By volume. From the measured diameter, obtain the area of the cross section of each disk (both rough and peeled). Total the areas of the unbarked cross sections, subtract the total area of the barked cross sections, and divide by the total rough-section area. The quotient, multiplied by 100, gives the percentage of bark by volume.

From the data obtained on the racked wood calculate the following:

(4) Average length, of the specimen logs. (If desired, also calculate the percentage of logs over and/or under standard.) Divide the average length of the logs into 4.0 to give a correction factor f.

(5) Weight per cord of 128 cu. ft. as received, corrected for the average log length if this is other than 4 ft., by multiplying by the factor f.

From these values calculate:

(6) Weight of moisture-free wood per cord. This is equal to:

$$W \times \frac{(100 - B)}{100} \times \frac{(100 - M)}{100}$$

(7) Solid volume per cord of wood in cubic feet at time of racking. This is equal to:

$$\frac{W \times \frac{(100-B)}{100} \times \frac{(100-M)}{100}}{D}$$

where

W = weight per cord of unbarked wood as received, pounds.
B = percentage of bark by weight.
M = percentage of moisture by weight of bark-free wood as tested.
D = density based on moisture-free weight, green volume, pounds per cubic foot.

(8) Solid volume per cord of rough wood at time of racking:

$$\frac{\text{Cu. ft. per cord (Formula (7) above)} \times 100}{100 - \%\text{ bark by volume (Formula (3B) above)}}$$

Report

For a complete report give the following to three significant figures:

1. Total gross weight of wood per cord, in pounds.
2. Average maximum, and minimum diameter of bark-free logs, in inches.
3. Bark, percentage by green weight and by volume.
4. Average length of logs and, if desired, the percentage of logs over (or under) standard.
5. Density, in pounds per cubic foot (based on moisture-free weight and green volume).
6. Moisture, percentage of green weight.
7. Solid volume per cord of unbarked green wood, in cubic feet.
8. Total moisture-free wood per cord, in pounds.

Accuracy

The accuracy of this method depends on:

(1) The adequacy and uniformity of the sample tested.

(2) The uniformity of the density along the length of the logs.

(3) The uniformity of moisture along the length of the logs.

(4) The accuracy of the procedures used.

The density at intervals 8 to 12 in. apart along the length of a stock of pulpwood may vary as much as 6 to

8% depending on the presence of knots, scars, etc. The moisture content may vary even more; in green wood as much as 10% over the length. However, as great as they may be, both these variations are usually less than the variation in density and moisture from log to log. Inaccuracies due to natural variations are minimized by examining a larger number of individual logs. Hence, never less than 25 logs should be taken as a sample.

With ordinary precautions, the method of determining the density normally will result in an error of less than 1%.

METHOD B

Apparatus

In addition to the apparatus listed, for Method A, the following equipment is necessary:

1. *Barking Equipment.* Spud or draw knife and barking horses.
2. *Immersion Tank.* A tank sufficient in size to hold one fifth or more of a cord of 4-ft. wood and provided with a hinged frame which can be used to push the wood under the surface of the water.
3. *Overflow Tank* connected to a tray beneath the immersion tank for accurately measuring the displaced volume of water by volume (e.g. with a hook depth gage) or by weighing.

Test Sample

Follow the procedure described in Method A for selecting the test sample.

Procedure

The preferred procedure is similar to that described in Method A, carried through the steps of sawing disks from the specimen logs and storing them in covered containers. Remove any bark from the disks and determine the moisture content according to TAPPI Standard T 18 m.

Weigh the remaining segments of the logs from which the disks were cut. By means of the tape, measure the diameter at each end and record the average diameter. If unbarked, remove the bark from the log pieces. After barking, weigh them immediately and record their weight; also measure the diameter at each end and record the average. Thoroughly wet the logs, for example by placing them under a spray of water for an hour or more. Transfer the wetted logs to the displacement tank, immerse, and determine their volume in cubic feet.

Calculations

With the exception of the calculation of density, the calculations are the same as for Method A.

Density: (a) The density on the basis of as-received weight and volume is the total weight of the bark-free logs from which the disks were cut, divided by their total volume in cubic feet as determined by displacement.

(b) The density on the basis of moisture-free weight, and as-received volume. The figure (a) above is multiplied by (100 − % moisture)/100.

Report

Report the findings as listed in Method A.

Accuracy

The density obtained by Method B should compare closely with that obtained by TAPPI Standard T 18 m, except for very dry wood which has radial cracks; since in that procedure, these cracks are closed by soaking the wood.

With green wood, method B should be somewhat more accurate than T 18 m, since the effect of variations in the density of the wood along the length of the log of pulpwood is avoided.

For rough wood, Method A is more rapid, since it does not require the specimen logs to be barked.

METHOD C

This method eliminates the necessity of weighing the logs in the sample cord and in addition, provides a photograph of the wood.

If a representative sample of the logs can be obtained in some other manner than that described in Method A, it may not be necessary to rack the wood at all. In this case a photograph (or photographs) are taken of the racked wood in the yard, railroad car, or truck. This wood, as mentioned in Section II, is generally more compact and contains a higher solid volume per cord than wood piled in a cord rack and in some cases may be the more useful value.

Apparatus

In addition to all the apparatus listed for Method A the following equipment is necessary:

1. *Camera.* 35 mm. or other camera with tripod and flash equipment.
2. *Print Enlarger.*
3. *Overlay.* A transparent film upon which is imprinted, in black, a rectangle containing 1000 uniformly points or dots. The rectangle is advantageously proportioned to the length and height of the wood piled in the cord rack, i.e., with the length of the rectangle being twice its width. The dots are placed at the intersections of 20 equidistant lines drawn parallel to the long sides and 50 equidistant lines drawn parallel to the short sides of the rectangle. Thus, for a 5 by 10-in. rectangle, the short lines would be spaced five to the inch and the long lines four to the inch. The lines nearest to the boundaries of the rectangle are drawn at a distance equal to one half the interval between lines. The rectangle and either the grid lines or the dots are inked, making the dots as uniform in size as possible. The drawing is photographed and a positive enlargement produced on film. The enlarged rectangle should be from 9 to 10 in. long by 4.5 to 5 in. wide, and the dots about $^1/_{16}$ inch in diameter. More precise scanning devices have been described (*1*, *2*, *3*).

Test Sample

Follow the procedure described in Method A for selecting the sample.

Procedure

Follow the procedure in Method A for filling the cord rack. When the rack is filled and strings stretched to indicate which logs are to be taken as the specimens, set the camera 6 to 8 ft. from and sighted level with the center log in the racked cord so that the

log ends will appear in the photograph with minimum of angular distortion. Focus the ends of the logs as exactly as possible to insure sharp negatives. An identifying number large enough to be read on the print may be attached to or marked on a log. Also, a foot rule may be attached to another log if desired. These attachments should be placed so as not to interfere with the subsequent measurements on the photograph. Take a picture with black and white film. Usually a flash is advantageous.

After the photograph is taken, continue with the procedure given in Method A, omitting the step of weighing the logs.

Make glossy prints of the negative and grid as follows: Lay the transparent grid on the printing paper and enlarge the image of the photograph so that the entire rectangular area of the grid is within the area of the wood, that is, with all the parts of the cord rack and the empty space above the wood excluded. The resulting enlargement is thus overprinted with 1000 crossings or dots.

Determine the relative proportions of wood, bark, and empty space by counting all the dots located on the ends of the logs, and those which lie on the bark. Do not count the dots as being on the logs if because of parallax, at the edges of the print they appear on the sides of the logs.

Calculations

The percentage areas of wood and of bark are equal to the respective number of dots lying on each, divided by 10.

The cubic feet or solid volume of wood per cord equals the number of dots lying on the wood multiplied by 0.128.

The cubic feet of bark per cord equals the number of dots lying on the bark multiplied by 0.128.

The moisture-free weight of wood per cord equals the cubic feet of wood (solid volume) times its average density (in moisture-free pound per cubic foot).

The weight of wood and bark per cord as received, equals:

$$\frac{D}{\frac{100 - B}{100} \times \frac{100 - M}{100}}$$

where:

D = moisture-free weight of wood per cord
B = percentage of bark by weight of the unbarked wood as received
M = percentage of moisture by weight of bark-free wood as tested

Report

Report the findings as listed in Method A.

SECTION II. RELATION OF RACKED AND SCALED VOLUMES

The previous determinations relate to an ideally racked cord, which usually is not identical in volume to commercially scaled wood because of:

1. The change in apparent volume after sawing and repiling 8-ft. wood in 4-ft. lengths. The 4-ft. lengths usually pile more compactly than the 8-ft. lengths.

2. The voids along the sides and bottom of the laboratory cord as racked, are usually filled in the ordinary scaled cord.

3. The shaking or jolting during shipment (if the scaling is done at the unloading terminal), which causes the wood to settle more compactly.

The determination of the ratio of the scaled cord to the racked cord is practicable only when a relatively small unit of wood (for example, a railroad carload) is scaled.

RELATION OF VOLUMES OF 8-FT. (OR OTHER) LENGTH AND 4-FT. RACKED (LABORATORY) CORDS

This relationship may be determined by either of two methods, D and E.

METHOD D

Apparatus

1. *Racks.* An 8-ft. (or other size) and a 4-ft. laboratory cord rack as described for Method A.
2. *Saw*, for severing the 8-ft. logs.

Procedure

Rack the 8-ft. wood in the laboratory cord rack, putting aside each rackful until at least 10 cords (5 rackfuls) have been measured.

Saw the wood into 4-ft. lengths and rerack in the 4-ft. rack. Carefully level off the last partially filled rackful and estimate the fraction of a cord it represents. Record the number of racked cords of 4-ft. wood.

Determine the cubic feet per cord of 4-ft. wood according to one of the methods in Section I.

Calculation

Calculate the volume (cubic feet) per cord of racked 8-ft. wood by the formula:

$$\frac{NV}{R}$$

where

N = number of racked cords of 4-ft. wood reracked after sawing
V = cubic feet per cord of racked 4-ft. wood
R = number of racked cords of 8-ft. wood

Report

Report the ratio of solid volume of racked 8-ft. (or other length) wood to the solid volume of racked 4-ft. wood as a percentage, to three significant figures.

METHOD E

Apparatus

1. *Racks.* An 8-ft. and a 4-ft. laboratory cord rack as described for Method A.
2. *Scale*, of about 3 tons capacity for the 4-ft. laboratory cord rack and which is mounted on it. If such a scale is not available, one of about 250 lb. capacity may be used to weigh the individual logs.

Procedure

Fill the 8-ft. rack. Empty it and saw each log into two equal sections, discarding one end of each log. Rerack the 4-ft. sections in the 4-ft. cord rack. The rack will not be full, so complete the filling with 4-ft. logs (from those discarded) of average size. Weigh the rack full of 4-ft. logs. Weigh the remaining 4-ft

logs. To increase the accuracy, this determination should be repeated and an average taken.

Determine the cubic feet per cord of the rack of 4-ft. logs according to one of the methods in Section I.

Calculations

Calculate the volume (cubic feet) per cord of racked 8-ft. wood by the formula:

$$\frac{VU}{W}$$

where

V = cubic feet per cord of racked 4-ft. wood
U = total weight of wood, pounds
W = weight of wood per cord of racked 4-ft. logs, including bark

Report

Report the findings as for Method D.

RELATION OF VOLUMES OR A 4-FT. SCALED CORD TO A 4-FT. RACKED (LABORATORY) CORD

METHOD F

Apparatus

1. *Rack.* A 4-ft. laboratory cord rack as described in Method A.

Procedure

Determine the number of cords in the shipment by scaling (see definition of scaled cord).

Determine the number of cords of wood in the shipment by racking. If the lot is too large to handle in this fashion, take every third, fourth, or other incremental number of log, as the wood is unloaded. Carefully level off and estimate the last portion of a cord by stretching a string along the ends of the top layer of logs as described in Method A.

Calculation

Calculate the volume (cubic feet) per cord of 4-ft. scaled wood in terms of the racked (laboratory) cord from the formula:

$$\frac{NV}{S}$$

where

V = volume (cubic feet) per cord of the 4-ft. racked wood
N = number of cords in unit as racked
S = number of cords in the unit shipment as scaled

This determination should be carried out on at least two carloads of a shipment of the same lot of wood to minimize scaling variations not under laboratory control.

Report

Report the ratio of solid volume per cord of 4-ft. scaled wood to the solid volume per cord of racked 4-ft. wood, as a percentage to three significant figures.

RELATION OF VOLUMES OF 8-FT. OR OTHER LENGTH OF A SCALED CORD TO A RACKED (LABORATORY) CORD

METHOD G

Apparatus

1. *Rack,* 8 ft. long, with ends 4 ft. high and 6 ft. wide, or a width $^3/_4$ the average length of the wood to be stacked in it, constructed and equipped as described under Method A. It may consist of the rack for 4-ft. wood, to which a parallel section is bolted to extend its width.

Procedure

Determine the number of cords of wood in the shipment by scaling (see definition of scaled cord).

Determine the number of racked cords of 8-ft. (or other length) wood in shipment as described by Method D or E for 4-ft. racked cords.

Calculation

The formula for calculating the volume (cubic feet) per cord of 8-ft. (or other length) scaled wood is:

$$\frac{NV}{S}$$

where

N = number of cords in shipment as racked
S = number of cords in shipment as scaled
V = volume (cubic feet) per cord of 8-ft. racked wood, as given by the formula in Method D or E

Report

Report the ratio of the solid volume per cord of scaled wood to the solid volume per cord of racked wood, as a percentage to three significant figures.

SECTION III. RAILROAD SCALING

METHOD H

If the equipment is available, direct determination of the volume of a cord, scaled on a railroad car, can be made. The method is as follows:

Apparatus

1. *Scale.* An accurate railroad-car scale.
2. *Other Apparatus,* as described for Method A or B. The laboratory rack is not necessary.

Procedure

Record the scaled volume of the wood (in cords). Accurately weigh the car before and after unloading. As the car is unloaded take a number of specimen logs not less than 0.5% of the total number in the lot of wood nor less than 30 logs, taking them at predetermined numerical intervals so as to be representative of the shipment. If the wood is obviously nonuniform as to size, dryness, and other conditions, it is advisable to increase the number of specimen logs taken. If the specimen logs are in 8-ft. lengths, saw the specimens in two and proceed to test the sample logs as outlined in Method A or B.

Calculation

The weight of wood in the car divided by the scaled volume in cords is the weight of wood per scaled cord as received. The volume (cubic feet) per cord of scaled wood is obtained by the formula:

$$\frac{VR}{W}$$

where

V = volume (cubic feet) per cord of 4-ft. racked wood
R = weight per scaled cord of wood as received, pounds
W = weight per cord of 4-ft. logs, including bark, pounds

Report

Report the findings as given in Method A.

Accuracy

The accuracy of this method is about the same as that of the other methods. The determinations should be made immediately following the weighing and sampling.

ADDITIONAL INFORMATION

The methods in this revision, except new Method C have been taken from a portion of T 7 p-53, clarified and re-coded as T 7 m.

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Weight of Unit Volume of Chips*

New Suggested Method T 21 sm-58

(THIS METHOD IS UNDER THE JURISDICTION OF THE FIBROUS RAW MATERIALS TESTING COMMITTEE)

The weight of wood chips in a digester or chip bin can be readily calculated if the volume of the digester or bin and the average weight of dry wood per unit of volume of chips are known. The following method for determining the weight per unit volume of the chips is designed to give a value under a pressure simulating that when filled into a digester. The principles of the test can be applied to chips in storage by making appropriate adjustments relative to bin dimensions.

APPARATUS

1. *Large Chip Can.* A galvanized metal cylindrical can (as for domestic garbage) 21 ± 1 in. in diameter (= D) and about 24 in. deep (inside dimensions) with a painted line around the inside to indicate a content of 4 cu. ft.

2. *Small Chip Can.* A slightly conical cylindrical can having an average area of $^1/_3$ sq. ft. and a height equal to that of the 4 cu. ft. volume in the large can. The can has a smooth interior with inside dimensions of $7^5/_8$ in. diam. at the top, and 8 in. diam. at the bottom, and is made from 16 gage or heavier, sheet metal.

3. *Chip Compressor Disk.* A circular plate about $^1/_8$ in. or more, thick and about $7^1/_2$ in. in diameter or so that it will slide freely, with only slight lateral play, within the small chip can.

4. *Pressure Applicator.* A weight about 7 in. diam., or a compressed air, lever or other system that will apply a known, steady pressure equal to that of a column of chips half the height of the digester. For reference purposes, use a pressure of 75 lb. on the small, $^1/_3$ sq. ft. chip can which is about equivalent to the weight of a 25 ft. high column of dry uncompressed chips.

Note: A simple arrangement to apply the required pressure consists of a 2 in. by 4 in. piece of lumber 6 to 8 ft. long, hinged to a wall at a height of a little more than that of the small chip can. About 1 ft. away from the hinge is a $^1/_2$ in. diam. threaded long bolt with its nut embedded in or attached to the lower side of the lever, the lower end of the bolt bearing on the center of the chip compressor disk. The bolt is screwed up or down so as to keep the lever substantially horizontal when the load is applied. A weight, such as a bucket of water, is suspended from the end of the lever to apply with the effective weight of the lever, the required force.

5. *Scales.* Accurate to within 0.2 lb. or less and with a capacity of about 100 lb., or sufficient for the large can plus chips.

6. *Drying Oven with Chip Baskets* or a large apparatus for a moisture determination as described in TAPPI Standard T 3 m.

PROCEDURE

Weigh the large chip can and fill it with chips to the 4 cu. ft. mark. Jar slightly three times, by raising a side of the can 1 in. up from a concrete floor and releasing it once at each of three positions spaced equally around the can. Refill to the mark and obtain the net weight of the chips (= W lb.)

Calculate the weight of chips to be added to the small can to equal the height of the chips in the large can (= $W \times 61/D^2$). Dump out and mix the chips in the large can, quarter down and weigh out the calculated weight. Save the remainder for further quartering for the moisture determination. Pour the calculated weight of chips into the small can and jar it until the chips are at the same height as in the large can, that is, level with the top of its rim.

Unless the reference pressure of 75 lb. is to be applied, using the weight of the 4 cu. ft. of chips in the large can as a basis, estimate the approximate weight of a column of chips $^1/_3$ sq. ft. in cross section and one half the height of chips in the digester.

Place the chip compressor disk on the chips in the

* This method has been accepted by the Standards Committee as being the most suitable to date. It is not, however, a TAPPI Standard. Criticisms are invited and should be sent to the Secretary, TAPPI, 155 East 44th St., New York 17, N. Y. Minor changes may be made in the method before publication in loose-leaf form.

small can and add weights (or apply pressure), which, with the chip compressor disk and the effective weight of the lever if used, is equivalent to that desired.

Measure the distance the chips are compressed, i.e., the distance from the bottom of the compressor plate to the top rim of the can, and calculate the ratio of the compressed height of the chips to their original height ($= p$).

Assuming that the chips in the large can were compressed as in the small can, the corrected (compressed) volume of the original 4 cu. ft. would be $4p$, and the weight per cubic foot of the compressed chips, would be $W/4p$.

Mix the remaining chips from the quartering procedure, further quarter them down to a specimen of not less than 1 lb. and determine its moisture content.

REPORT

Report the weight of the chips under a pressure of 225 lb. per sq. ft. (or other specified pressure) to the nearest 0.1 lb. (a) as tested and (b) on a moisture-free basis.

ADDITIONAL INFORMATION

This method has been separated from TAPPI Standard T 7 p-53 and revised so as to be more specific.

It is not known how accurately a pressure equal to one half the height of the digester, gives a change of volume of the chips, equal to the average change of volume of the entire charge. Any available data would be appreciated.

Opacity of Paper

Proposed revision of TAPPI Official Standard T 425 m-44

(THIS STANDARD IS UNDER THE JURISDICTION OF THE OPTICAL PROPERTIES COMMITTEE)

The essential principle of this contrast-ratio method for determining the opacity of paper, is as follows: the reflectance of paper when combined with a white backing is higher than that of paper when combined with a black backing because, in the former case, light transmitted through the imperfectly opaque sheet is largely reflected by the white backing, and a portion of the light thus reflected is transmitted through the paper a second time. Contrast ratio, $C_{0.89}$, is defined as 100 times the ratio of the diffuse reflectance, R_B, of a specimen backed with black of not more than 0.005 reflectance, to the diffuse reflectance, R_W, of the same specimen backed with a white body having an absolute reflectance of 0.89; $C_{0.89} = 100\ (R_B/R_W)$. These reflectances are absolute; the absolute diffuse reflectance for magnesium oxide being very nearly 0.98. Accordingly, the contrast ratio is 100% for perfectly opaque paper, and is only a few per cent for a perfectly transparent sheet.

APPARATUS

Opacity Meter, equipped with an accurately linear or a corrected photometric system. The reflectances involved in the determination of contrast ratio should be either for normal illumination and diffuse viewing, or the equivalent converse, i.e., diffuse illumination and normal viewing.

NOTE: The direction of illumination or, alternatively, the direction of viewing, should not be more than 20° from the normal.

The instrument may be designed directly to measure the ratio of reflectances of paper backed by black and white, or alternatively, the instrument may be adjusted to indicate a cardinal value such as 100.0 with the white backing in place and then the ratio of reflectances obtained by replacing the white body with the black body. The photometric system must be sufficiently stable that the instrument will not fluctuate by more than approximately 0.2% of its full-scale deflection while the contrast ratio is being measured.

The more important requirements of the apparatus are as follows:

(a) *Standard Black Backing,* consisting of a cavity lined with black velvet or other material which will cause the reflectance of the cavity to be less than 0.005.

(b) *Standard White Backing,* have an absolute reflectance equal to 0.89 when illuminated under the conditions of actual testing, with a sheet of paper in place (*1*). This backing consists of either a permanent diffusing surface of this apparent reflectance in contact with the sample, or of an equivalent cavity such as that provided by a diffusing surface separated from the sample by a cover glass.

(c) *Incandescent Light Source,* with a color temperature of between 2400 and 2800°K. In a single-photocell instrument, this implies that the voltage must not change by more than approximately 0.1%.

(d) *Photoelectric Cell,* corrected with an optical filter to have a relative spectral sensitivity closely approximating that of the human eye.

(e) *Specimen Holder,* so constructed, that the specimen may be viewed or illuminated through a round window approximately 14.3 mm. in diameter and to hold the specimen flat to within 0.15 mm.

CALIBRATION

Calibrate the instrument at frequent intervals as follows:

1. Adjust the *area of specimen to be assessed* so that it is centrally situated within its window and has a uniformly illuminated or viewed diameter 2 to 3 mm. less than the window.

Note: The assessed area needs to be smaller as specified, otherwise the calibration of the instrument with the opal-glass opacity standards (*2*) may be inaccurate because of edge error.

2. Establish that the *photometric scale is linear* or

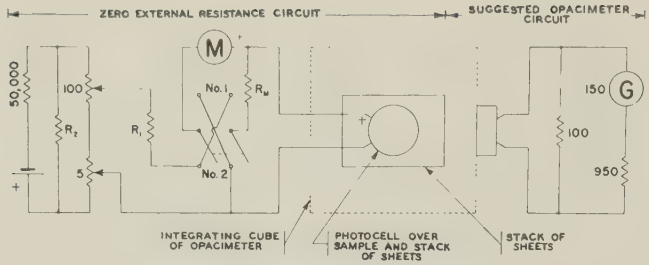


Fig. 1. Circuit for checking linearity of opacimeter

prepare a calibration chart to correct for nonlinearity for example as described in Appendix I.

3. Adjust the *effective reflectance of the white backing* so that the instrument gives correct readings of opacity with one or more opal-glass standards (which must be perfectly clean when used), or with some temporary opacity standards prepared from uncoated paper. When using the latter, employ the reflectance and opacity chart (*3*) shown in Fig. 2* which is based on the Kubelka and Munk theory (*1, 5, 6*) and follow the procedure described in Appendix I.

Appendix I gives detailed instructions for calibrating one type of opacimeter (*7, 8*) for these three steps.

TEST SPECIMEN

Select at least five representative specimens for each test (see TAPPI Standard T 400 m) free from watermarks or blemishes and of sufficient size to fit the specimen holder and completely cover the standard backings. Do not touch the test areas with the fingers, and keep them perfectly clean and free from folds and wrinkles.

PROCEDURE

Condition the specimens according to TAPPI Standard T 402 m. Measure the contrast ratio as follows: Set the meter at zero, then, with the specimen backed by the standard white backing, set the instrument to read 100.0. Replace the white backing with the black body, and read the meter to obtain the contrast ratio. Record the individual results to three significant figures. Average the values obtained for the five or more specimens.

Note 1: The mechanical zero of the instrument should be checked and adjusted if necessary. Then with the apparatus turned on and the specimen aperture covered with the black body, the scale reading should not exceed 0.5 divisions.

Note 2: If it is impossible to set the instrument at 100.0 for the normal range of white papers, when backed by the white body, the integrating cavity of the instrument should be resmoked or the photocell and/or lamp bulb should be replaced. If, because of low reflectance of the paper, the adjustment to 100.0 with the specimen backed with the white body is impossible, set the instrument at 90.0, 80.0, or other cardinal value; the contrast ratio is then obtained from the readings with the black and the white bodies respectively over the specimen.

Note 3: Usually neither the side or direction of the grain of the paper makes any significant difference. If either effect is appreciable, place the specimen with the selected side toward the instrument and orient its grain in such a manner as to give the highest reading. In such a case a note to the report stating the preferred side and orientation should be appended.

Compute the contrast ratio range, R (largest minus smallest value), and if five specimens were tested for a sample, multiply by 0.51 to obtain the 95% confidence limits of the mean (*9*). If more than five specimens are tested, replace the factor 0.51 with an appropriate factor from the following table:

Number of specimens	*Factor*
6	0.40
7	0.33
8	0.29
9	0.26
10	0.23

* *SX* on the original chart has been changed to sW to conform with nomenclature now preferred in the paper industry (*4*).

REPORT

Report the mean value of contrast ratio for each test sample to the nearest 0.1% together with the 95% confidence limits, $C_{0.89} \pm 0.51R$ (or other appropriate factor for R).

APPENDIX

Calibration of the Bausch and Lomb Opacimeter

1. *Optical Adjustment.* Arrange the instrument to permit the beam of light to fall on the surface of a wall about 10 ft. away from the instrument, and adjust the variable aperture to its full opening. Two images of the filament situated approximately in the center of the projected spot of light and reversed with respect to each other should be seen. One of the images is formed by rays which have been reflected by the mirror behind the source. The two lenses and the lamp should be adjusted to obtain the following results: (1) the two images of the filament projected on the wall should be in focus; (2) when a sheet of paper is laid over the specimen aperture to inspect the distribution of light in the aperture, the circular light spot should be (a) centered in the aperture, (b) nearly fill the aperture, but should not be in contact with the edge of the aperture—there should be a clearance of about 1 mm. between the edge and the boundary of the light spot, and (c) the boundary of the light spot should be as sharp and free of color as possible. After the tube and lenses have been adjusted, usually it is necessary to adjust the lamp only for subsequent checks of the optical system. The alignment and state of focus of the lamp should be checked before each standardization of the instrument. The lenses should be cleaned to minimize the light scattered into the integrating cube. Cleanliness of the opitcal system may be tested by comparing the mechanical zero of the meter with the reading when the instrument is in operation with a black body placed over the specimen aperture. There should be very little difference.

2. *Photometric Linearity.* The current output of the photoelectric cell used for the opacimeter varies with the radiation on it and with the resistance of the external circuit employed to measure the photocurrent. When the resistance of the external circuit is low or zero, the total current generated within the cell is essentially a linear function of the illumination. The departure from linearity of response increases as the external resistance of the current-measuring circuit increases. Since the circuit employed for measuring a photocurrent has an external resistance somewhat greater than 200 ohms, a small departure from linearity may be expected so it is desirable to check it.

Figure 1 shows a diagram of the circuits employed for this purpose. The opacimeter circuit is shown at the right and its integrating cube is shown schematically by the dotted lines forming the square. The zero-external-

resistance circuit, which is used as a standard in this method, is shown at the left, with a new photocell mounted over a diffusing screen and the specimen aperture in the integrating tube.

The diffusing screen consists of one or more thicknesses of white paper, the number of thicknesses being selected with regard to their total transmission so that an approximately full-scale deflection is obtained on the meter M (galvanometer or very sensitive microammeter). It is essential that this meter be calibrated so that corrections may be made for any departure from linearity.

It will be seen that with this arrangement, the photocells in both circuits receive their energy from the same light source—namely, the lamp in the opacimeter. The light viewed by the photocell in the opacimeter depends, in part, upon the amount of light reflected by the paper over the specimen aperture, whereas the light viewed by the photocell in the zero-external-resistance circuit is that transmitted by the paper. For a given change in the incident light, the relative change in the amount of light reaching the two photocells is the same. To obtain values over the full range of the meter scale, the intensity of the incident light is changed in appropriate steps by interposing neutral wire screens (several wire screens having different transmission values) between the lamp and the lens system of the opacimeter. Neutral screens may be made by lightly sooting wire screens over burn-camphor.

The zero-resistance circuit contains three resistances of undesignated value: R_M is a simple combination of wire-wound resistance which, *by actual test*, has a resistance very nearly the same as that of meter M. R_1 is any stable resistor whose value, obtained by trial, results in a condition of critical damping of M (preferably, the meter should overshoot slightly). R_2 depends on the sensitivity of M; it should be such that nearly full-scale deflection is obtained when one or more sheets of paper (serving as a diffuser) are over the specimen aperture, and the light beam is at full intensity. The cell indicated in the diagram in any single cell, 1.2 to 2 v.

The following procedure is recommended: (1) With the D.P.D.T. switch open, set the mechanical zero of M to zero on the scale (or, if desired, read and record the mechanical zero). (2) Reduce the illumination of the photocells to zero by interposing a piece of black paper in the light beam between the lamp and the lens system. Then move the 5 and 100-ohm rheostats to obtain zero potential difference (on the diagram, toward each other, to the common point of connection), and put the switch in its no. 1 position. M should read zero. Put the switch in its no. 2 position; M should continue to read zero. The deflection of the opacimeter meter G should be zero; if it is not, make the mechanical adjustment of meter G to obtain zero deflection. (3) Remove the black paper screen and adjust the diaphragm to obtain exactly 100 divisions on G. Then move the switch to its no. 1 position and adjust the 5- and 100-ohm rheostats to obtain zero deflection of M. Then move the switch to its no. 2 position and read M. After *correcting* the reading of M by means of the calibration chart provided for this meter, the proper photocurrent is obtained. (4) Place the neutral screen of highest transmission in the light beam in such manner that it cannot shift or move in any way. Read and record the deflection of G. With the switch in the no. 1 position adjust the 5- and 100-ohm rheostats to obtain zero deflection of M. Put the switch in the no. 2 position, read M, correct the reading, and record the corrected reading. (5) Remove the screen and readjust the diaphragm to obtain 100 divisions on G. Place the next screen in the light beam and proceed as under step 4. (6) Continue with the remaining screens and, at adequately frequent intervals, check the zeros of both meters. The work with all screens should be repeated to yield a final correction curve having good accuracy.

Plot the difference between the corrected readings of M and that of G as the correction chart for the opacimeter.

Important Note: Whenever the level of illumination is changed as when a screen is changed or a screen is removed, the 5 and 100-ohm rheostats must be adjusted with the switch in the no. 1 position to obtain zero deflection of M. The current read with the switch in the no. 2 position will be accurate *only* after this adjustment has been made. If the instrument is quite nonlinear, improvement may result from installation of a new Weston Photronic 594RR or 594YR cell with a Viscor filter.

3. *Adjustment of White Backing.* The adjustment of the white backing to conform to the requirement that it have an absolute reflectance of 0.89 (under the conditions of actual test, with a test specimen or standard in place), may be carried out either (A) by means of opal-glass standards, or (B) by means of paper and the Kubelka-Munk theory.

(A) Adjustment by Means of Opal-Glass Standards:

I. Clean the opal-glass standard by brushing it with a mild soap solution, rinsing it with water, and drying it with a clean towel.

II. Read the opacity of the calibrated area (indicated by four engraved lines pointed toward center of the area) of the opal-glass standard. If this opacity reading conforms to the value of opacity certified for the standard within 0.4%, the white backing may be regarded as correctly adjusted.

III. If the reading departs from the certified value of opacity by more than 0.4%, adjust the distance between the magnesium carbonate surface and the cover glass. Too high an opacity reading means that the distance must be decreased; too low a reading means that it must be increased.

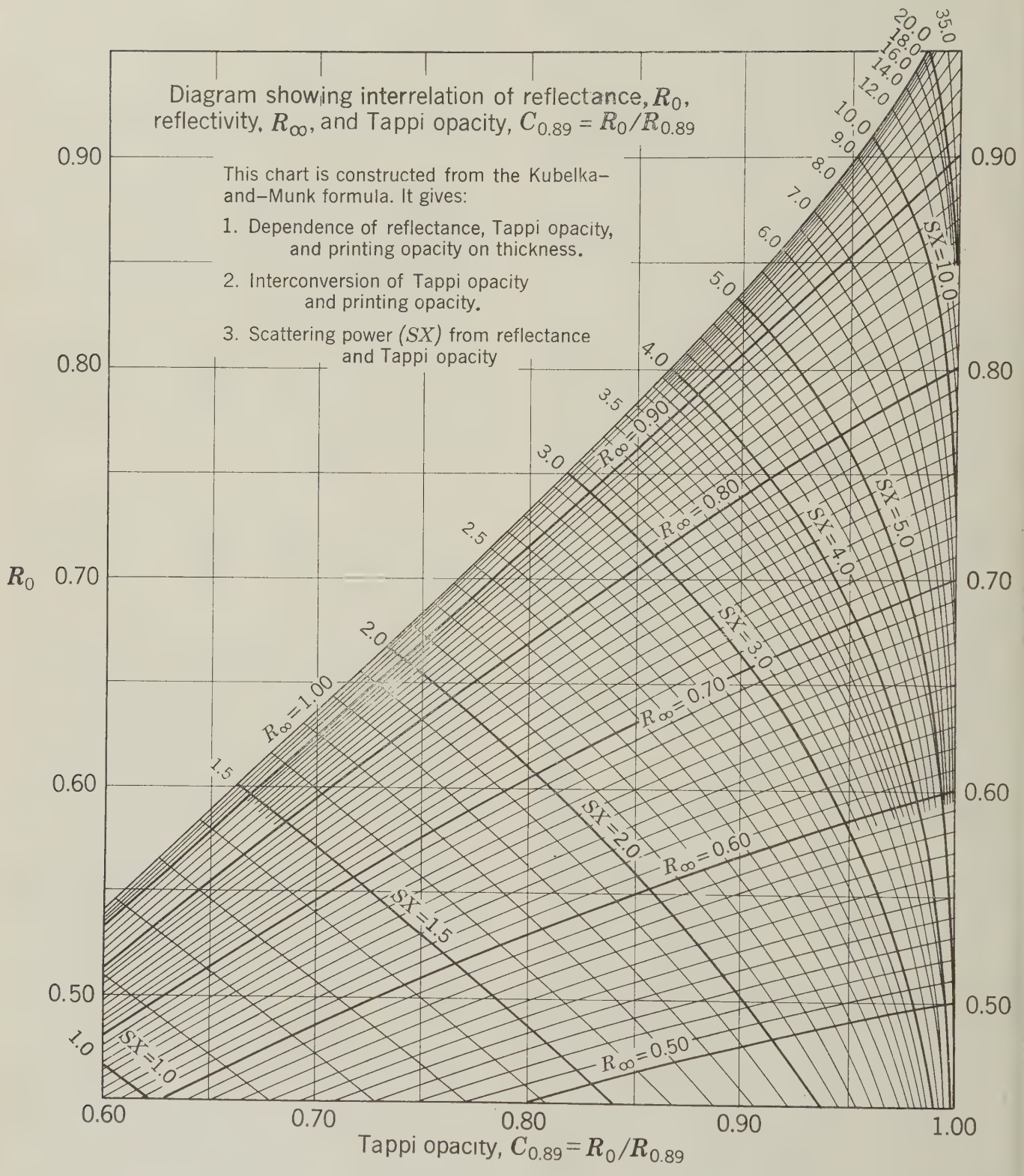
IV. Check the adjustment by means of opal-glass standards of different opacities, if available. It is usually possible to adjust the white backing so that the opacimeter will read within 0.4% of the correct opacities of specimens of any opacity from 60 to 95%, but sometimes discrepancies as high as 1% may have to be tolerated for opacities near 50%.

(B) Adjustment by Means of Kubelka-Munk Theory

A basic procedure for adjusting the white body rests upon an application of the Kubelka-Munk theory (*1*, *5*, *6*) which is most conveniently employed in this connection in the form of the reflectance-opacity charts prepared by the Photometry and Colorimetry Section of the National Bureau of Standards; see Fig. 2.* In addition to this chart, the following materials are required:

(a) *Uncoated paper samples*, covering the working

* *SX* on the original chart has been changed to *sW* to conform with nomenclature now preferred in the paper industry (*4*).



From "Color in Business, Service, and Industry," by D. B. Judd. Courtesy of John Wiley & Sons, Inc.

range of opacity and having good formation, preferably with no filler content and of a neutral white color and a dull but smooth finish;

(b) *A magnesium carbonate block* coated with magnesium oxide according to TAPPI Standard T 633 m, using magnesium ribbon for smoking with magnesium oxide;

Note: The reflectance of magnesium oxide and magnesium carbonate is fugitive and, hence, the magnesium oxide layers should be used soon after preparation and then be removed from the blocks of magnesia when the calibration is completed, and the blocks stored for further use.

(c) *A working standard of reflectances*, to be evaluated in absolute units, and to be used for the various settings of the instrument after the standardization with the magnesium oxide; and

(d) *Adhesive cellophane tape*, for holding a single sheet of paper over the sample opening.

Note: A working standard (c) is suggested for checking the reflectance scale, in view of the fragile nature of the magnesium oxide.

Procedure:

Carefully place the magnesium oxide surface over the specimen opening of the instrument, taking care to press it against the opening since the oxide layer is easily compressed, and appreciable error might result if the reflecting portion of the layer is pushed a little way in. Adjust the instrument to obtain a reading of 98.0 on a 100 division meter. Evaluate a working standard at this time, and record its absolute reflectance (for example, 0.734).

Reflectance readings obtained with paper should now be close approximations to their proper absolute values if the calibration chart (prepared with the zero-resistance circuit) is used.

With the instrument adjusted to read correctly on the absolute scale, place a specimen of one of the several samples to be used in the calibration over the specimen opening. Put hinge of adhesive cellophane tape to the top edge of the specimen, so that the sheet may be lifted for checking the reflectance scale and subsequently let down to occupy exactly its previous position. *It is most important that the sheet in contact with the specimen opening be fixed into position for the measurement of the reflectances involved in the calibration.*

Back the specimen with the black body, and read and record the reflectance R_0. Then back the specimen with the white body, and read reflectance R_W. R_W is the reflectance influenced by the effective reflectance of the white backing body. Finally, back the specimen with an opaque pad of exactly similar paper, and read and record the reflectance R_∞.

For example, suppose that the following reflectances are obtained: $R_0 = 0.600$; $R_W = 0.831$; $R_\infty = 0.800$. Considering the reflectance-opacity chart (Fig. 2), it will be seen that the $R_0 = 0.600$ ordinate intersects the $R_\infty = 0.800$ line, at a contrast ratio $C_{0.89} = 0.7075$. Since $C_{0.89} = R_0/R_W$, the calculated value of R_W is 0.848*. Actually, a value somewhat lower than this was obtained—namely, 0.831. This means that the effective reflectance of the white body is less than the ideal value, 0.89. In this event remove the white body from the instrument, and adjust it to increase its reflectance. In one instrument, this body consists of a metal cylinder containing a solid cylinder of magnesium carbonate and capped with a cover glass (*8*). On removing the threaded base of this container, it will be found possible, after loosening a small set screw in the wall of the container, to remove or rotate an inner threaded sleeve which holds the magnesium carbonate and thus vary the separation between the cover glass and the reflecting surface of the magnesium carbonate. If a sufficiently high reflectance cannot be obtained even with the reflecting surface in contact with the cover glass, remove the magnesium carbonate block and take off a surface layer to expose a fresh surface with a higher reflectance. Take care that after removal, the surface remains flat and parallel to the cover glass.

After this preliminary adjustment, obtain the corrected values for the three reflectances R_0, R_w, and R_α, for the several samples of paper, and determine the corresponding correct values of R_w from the reflectance-opacity chart, as described above. By comparison of these chart values with the directly determined values of R_w, refining adjustments of the white body may be made. After performing the final adjustments, the directly determined contrast ratios for white paper should agree with the chart values rather well, typical discrepancies being about 0.3%, with occasional differences of the order of 1%, the larger discrepancies usually occurring at the lower opacities. Until the contrary is definitely demonstrated, it is believed it is not possible visually to distinguish between contrast ratios differing by less than about 1.5% (*11*) and hence, that the above-described method will serve to satisfactorily maintain an instrument in a state of calibration better than required for visual purposes, and sufficiently accurate for technical purposes.

ADDITIONAL INFORMATION

This is an extensive revision of T 425 m-44, but the method is not changed in principle. Calibration of the apparatus is discussed in detail.

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7. Davis, M. N., "A Simple and Reliable Photoelectric Opacity Tester," *Tech. Assoc. Papers* 16: 277 (1933).
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* Alternatively, the value of R_w may be computed quite precisely without reference to the reflectance-opacity chart, by the following formula (*10*):

$$R_w = \{R_0 - 0.89\,[(1/R\infty + R\infty)R_0 - 1]\}(1 - 0.89R_0).$$

For the above sample, the computation is:

$$R_w = \{0.600 - 0.89[(1/0.800 + 0.800)\,(0.600) - 1]\}\,[1 - 0.89(0.600)]\} = 0.848.$$

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Compression Wood in Pulpwood*

Revision of Tentative Standard Method T 20 m-55

(THIS STANDARD IS UNDER THE JURISDICTION OF THE FIBROUS RAW MATERIALS TESTING COMMITTEE)

Compression wood is a type of abnormal structure that forms on the lower sides of leaning trunks and the branches in all coniferous species. For most uses of wood, its presence is undesirable; in pulpwood it may cause lower pulp yields, lower pulp strength, and pulp bleaching difficulties. Its effects vary according to the form and quantity of abnormal fibers present. Though compression wood may amount to a considerable proportion in some logs, the over-all quantity is generally not large enough to give serious trouble in pulping. It can occur, however, in a large portion of certain trees and so effect the general quality of pulpwood cuttings. An influx of such material into a mill system can well be the unexplained cause of sudden fluctuations in pulp quality.

Compression wood is ordinarily distinguishable in a log's transverse section by eccentric and wide annual-growth rings and unusually large summerwood areas in the wider parts of the rings. It may be confined to a few annual rings, or it may comprise from one third to one half of the cross section. Compared to the normal wood, it has a "lifeless" appearance which is the result of lack of contrast between the spring wood and summerwood. It differs from normal wood in gross anatomy, minute structure of the individual fibers, and in chemical composition. It occurs in gradually merging forms, from that which differs distinctly from normal wood to that which is recognizable only by microscopic examination. In general, compression wood may be divided into two broad classes: (a) severe and intermediate forms, which are conspicuous and easily recognizable on sight (Fig. 1 and 2); (as in T 20 m-55) and (b) borderline forms, which require some experience to recognize with the unaided eye and may need microscopic examination to identify positively.

This method is concerned only with the detection and measurement of the compression wood that can be recognized by unaided vision. Normally this is sufficient for operating purposes. Microscopic and chemical tests may be required in special cases.

APPARATUS

1. *Viewing Device*, used as an aid to determine the presence of compression wood, consisting of any convenient means for viewing thin cross sections of pulpwood by light transmitted through the section.

Such a device may be a special box containing a 100- or 150-watt electric lamp. The box has openings in its sides for ventilation, and a rectangular or circular aperture or window in the top over which the log section may be placed. The aperture should be at least as large as the average section of pulpwood and covered with clear glass set flush with the top surface of the box. Paperboard or thin sheet-metal shields should be provided for shutting off light passing around the outside of the smaller specimens.

Another type of viewing device is a rectangular or circular tube made from paperboard or sheet metal. The specimen is held or clamped on one end of the tube, and viewed from the other end against strong sunlight, or a powerful electric light in a dimly lighted or darkened room.

2. *Tracing Plate or Table* (for use with quantitative procedure A). A plate glass about 12 in. square with one surface ground or etched, fastened flush in a wooden frame about $1^1/_4$ in. wide. Although not necessary, it is convenient to make the framed glass, with the etched surface up, the hinged lid of a shallow box about 2 in. deep. Within the box, a piece of a soft rubber sponge, approximately 7 by $4^1/_2$ by 2 in., is glued to the middle of the bottom. When a specimen disk of pulpwood is laid upon the sponge and the glass lid of the box is closed and latched, the sponge presses the disk upwards firmly against the lower (unetched) surface

* This method has been approved as a Tentative Standard by the Standards Committee. Criticisms are invited, and should be sent to the Secretary, TAPPI, 155 East 44th St., New York 17, N. Y. Minor changes may be made in the method before publication in loose-leaf form.

of the glass plate, thus making the marked outlines of the compression wood plainly visible.

3. *Means for Measuring Areas* such as (a) a planimeter or (b) sheets of translucent paper, individually selected so as to weigh within 12 of the mean sheet weight and a pair of scissors or a sharp knife and a hardwood cutting block, to determine areas by cutting them out from the paper and weighing.

4. *Saw,* sharp, for cutting specimen disks from the logs.

QUALITATIVE DETECTION

Severe and intermediate forms of compression wood are easily recognized, once the observer becomes familiar with their general characteristics. The borderline form requires some practice to distinguish it from normal wood. The viewing box is useful for training an observer and as an aid in deciding doubtful cases.

Test Specimen

Saw a transverse section of the wood about $^1/_8$ to $^3/_{16}$ in. thick from each pulpwood log. Sanded surfaces are unsatisfactory because during sanding, the cell cavities become filled. This reduces the translucency of normal wood and thus its contrast to compression wood.

Procedure

Very severe compression wood can be detected easily by its comparatively wide and eccentric annual rings containing much summerwood which is not as hard as normal summerwood nor when dry, as dark. This gives compression wood a somewhat "lifeless" appearance.

Place the specimen in the aperture of the viewing apparatus; the compression wood then appears relatively opaque as compared to the translucent normal wood (Fig. 3). (as in T 20 m-55).

Note: Pitch-soaked wood is highly translucent regardless of whether or not it contains compression wood so that very pitchy wood makes the determination difficult.

QUANTITATIVE MEASUREMENT

The degree of the reduction in pulp quality by compression wood is in proportion to the amount present and to its severity.

Test Specimens

Saw a disk from $^1/_8$ to $^1/_4$ in. thick from each of a representative number of logs.

The number of test specimens will depend on the variability of the volume of compression wood between logs and can be determined by approved sampling procedures. Each specimen may consist of a disk cut from each of the logs selected for specific gravity determination according to TAPPI Standard T 18-m.

Procedure

If the sample logs are of different lengths, measure each and identify the length with the disk cut from it.

With an indelible pencil outline the areas of compression wood, if present, on a dampened surface of the disks and measure these areas and the entire areas of all the disks by one of the following procedures:

(A) Place the ground-glass tracing plate on the disk with the ground surface up, or, if the plate is the top of a hinged box as described, place the disk on the sponge and close the lid. With the planimeter, measure the area of the disk inside the bark and the outlined areas of the compression wood.

(B) Lay a translucent sheet of paper over the disk and trace its outline and that of the compression areas. Measure them with the planimeter. Alternatively, if the basis weight of the paper is sufficiently uniform, with the pair of scissors or knife and a hardwood block, cut out the traced area of the disk, weigh the paper disk on a sensitive balance, then cut out the outlined area of the compression wood and weigh it. If the logs are of the same length, weigh all the cut-out disks together, then cut out the outlined compression wood areas from the paper disks and weigh them together. The ratio of the respective weights will give the ratio of the two areas.

Calculate the percentage of the compression wood by the formula $100A/B$ where A equals the sum of the products of the compression area of each disk and the length of the log from which it was cut, and B equals the total volume of all the logs sampled. If the logs sampled were all of the same length, the percentage of compression wood is equal to $100C/D$ where C is the sum of the areas of the compression wood and D is the sum of the areas of all the disks examined.

REPORT

Report the result as a percentage by volume of compression wood to two significant figures.

ADDITIONAL INFORMATION

The major change in the revision is the inclusion of the alternative method of measuring areas by weighing corresponding areas outlined on paper.

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Erratum

A proposed revision of Tappi Standard T 608 m-42 "Calibration of Glassware and Analytical Weights" was published in the June, 1958, number of *Tappi.* Column 2 on page 177A, lines 7 and 8 up, presently read (as does T 608 m-42): "touch the tip of the pipet to the liquid and immediately withdraw it." The chairman of the Standards Committee is grateful to the TAPPI member who brought this matter to his attention. The National Bureau of Standards confirms that this should read: "touch the tip of the pipet to the wet wall of the flask and immediately withdraw it." This change will be made when the Standard is published in loose-leaf form.

RC-256. Density or Volume of Small Specimen (Hg pycnometer)

THIS test is a convenient and accurate one for measuring the volume or apparent density of a small object such as an individual wood chip, sliver, or small piece of paperboard.

Required is a supply of mercury, a balance, preferably a triple beam type with one beam graduated to 0.01 gram, and a small special bottle. The bottle should be a wide mouthed one, a little larger than the specimen and provided with a stopper that may be pushed into the mouth of the bottle to a fixed depth. Most druggists now use such bottles, having polyethylene stoppers with outer rims, for dispensing pills. Drill a small hole, about $^1/_{32}$ in. diam., through the axis of the stopper, countersink the inner edge of the hole, and bevel the inside edges of the stopper if necessary, to facilitate the escape of air.

Fill the bottle with mercury almost to the brim, stand the botton on an open Petri dish or other pan and push home the stopper, forcing the excess mercury up through the hole and into the pan. Brush off the bead of mercury from the hole and weigh the bottle and contents to the nearest 0.1 gram = W_1 grams.

Weigh the specimen to the nearest 0.01 gram (if the density is required, otherwise if only its volume is wanted, to the nearest 0.1 gram) = w grams. Open the bottle, stand it on the pan, and float the specimen on the mercury in the bottle. Replace the stopper, submerging the specimen and push the stopper home, taking care to allow any air entrapped in the bottle to escape. Brush off the bead of mercury from above the hole in the stopper and reweigh the bottle and contents = W_2 grams.

The volume v of the specimen is: $(W_1-W_2-w)/13.54$ cc.

The density of the specimen is w/v grams per cc.

Note: 13.54 is the density of mercury at 22.5°C.

RC-267. Block-Tensile Test of Bonding Quality

THE object of this method is to measure the bonding quality of an adhesive in terms of tensile strength and tearing ability. Since the bonds may be tested at any desired stage, or series of stages in their development, the method permits measurement of the inherent tackiness, the rate of bond development, or the matured bond quality of an adhesive.

Apparatus

1. A group of 1-in. cubes, each fitted with a face-plate, a washer, and an eye-screw. The cubes may be wooden counting blocks, for example, each drilled at the center of one face to accommodate an eye-screw. The face-plates may conveniently be of $^3/_{16}$-in. hardwood, 1 by 1-in., drilled at the center so the threads of an eye-screw pass through freely.

2. A flat frame of about 2.5 by 3.5 in. with a 1.5 in. square opening at its center. The frame may be cut, for example, from a $^3/_{16}$-in. hardwood sheet.

3. A group of identical weights, hollowed to fit around the head of an eye-screw while resting securely on the corners of an inch-square plate. The weights may weigh about 2 lb. each, or be constructed so their load can be varied.

4. Apparatus for spreading a uniform film of adhesive on a surface to be bonded. A glass rod of about $^1/_4$ in. diam. and 4.5 in. length is a satisfactory applicator, and may be wrapped at 1.5 in. intervals with wire of suitable diameter if an adhesive film of some thickness is to be applied.

5. Apparatus which hooks through an eye-screw and measures the force, in grams or pounds, required to lift a block from its anchorage. The lifting apparatus may conveniently be a push-pull gage of 0 to 1000 g. range for smaller measurements. Such a gage, which can be adjusted for vertical use and fitted with a maximum-reading pointer as well as a shock-absorber, is manufactured by John Chatillon and Sons, 85 Cliff St., New York 38, N. Y. For larger measurements of several pounds, push-pull gages of greater capacity are available from Chatillon; or a pendulum type of tensile-testing machine, such as is manufactured by the Thwing-Albert Instrument Co., Penn St. and Pulaski Ave., Philadelphia 44, Pa., may be fitted simply with a wire hook and then used.

An advantage of the method is that materials to be bonded with a test adhesive do not themselves have to be attached to rigid fixtures with some stronger adhesive. Another advantage is the wide usefulness of the method. With only minor variations the procedure can be used to study the bonding of paper to paper, the attaching of label stock to glass, or for measuring the adhesive strength of gummed tape.

The procedure:

Cut a group of 1 by 3.75 in. pieces, and some 3.5 by 14 in. pieces, from a sheet of the paper to be bonded. Fit a 1 by

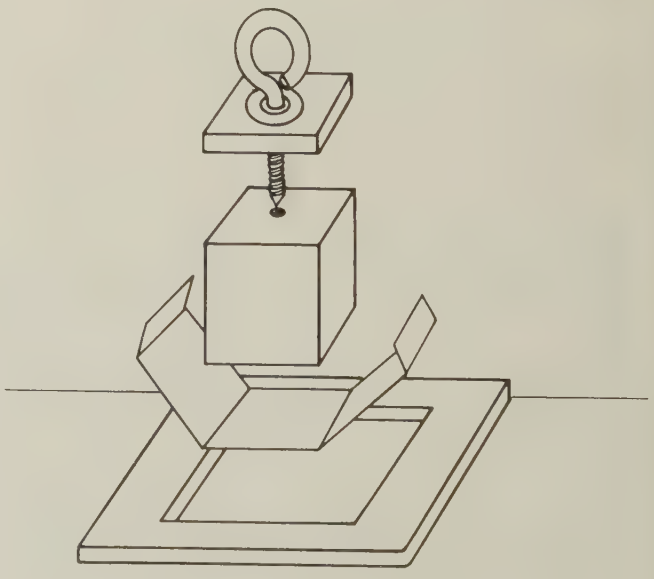


Fig. 1. Block-tensile assembly

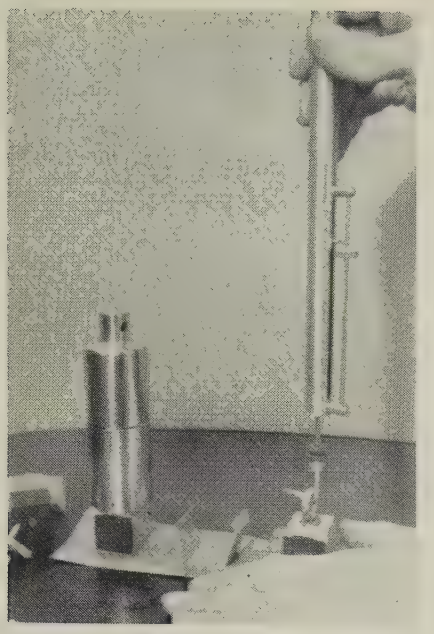


Fig. 2. Bond Specimen . . . . weighted . . . . . being tested

3.75 in. strip snugly around each of several blocks, with the test side of the paper facing outward, and clamp the ends of the strip in place.

Lay a 3.5 by 14 in. sheet of paper, with the side to be glued facing upward, on a flat surface. A table top or a clipboard is satisfactory, the surface being covered with a sheet of scrap paper to protect it from adhesive spillage.

Spill the test adhesive on the 3.5 by 14 in. sheet, and spread it the length of the sheet in a uniform film. As rapidly as possible, set five of the paper-covered blocks on the glue film, spacing them equidistant along the sheet, and immediately place a weight on each block over the eye-screw. Note the time when the first block is weighted.

Promptly remove the weight from the first block. Place the frame around that block, thus holding down the glued sheet firmly with one hand and lift the block free with the push-pull gage. Note the force required, and the elapsed time (possibly 20 sec.) since the block had first been weighted.

Measure the lifting resistance of the remaining blocks successively after 1 min., 3 min., 10 min., and 24 hr. of elapsed time. When the bond strength exceeds the capacity of a push-pull gage and is then to be determined with a tensile-testing machine, cut the flat glued sheet leaving at least a $^3/_4$ in. margin on all sides of the block to be tested. At the proper time for testing remove the weight from the block; place the block and attached liner on a flat, rigid plate approximately 2.5 by 3.5 in. with the frame holding the flat liner firmly against the plate: engage the hook of the tensile-testing machine in the loop on the test block, and lower the plate and frame steadily until the block is pulled free.

Observe the exposed paper surfaces after bond separation and estimate the per cent of fiber tear which has occurred.

For greater reliability, carry out the series of block tests three times, using identical adhesive, paper, glue film thickness, and testing intervals. For a more dependable test, particularly if the results are to be compared with others obtained at another time, condition the paper to be used and carry out the work under standard conditions, cuch as at 73°F. and 50% R. H. Also, adjust the adhesive to a fixed temperature such as 73°F. before application.

In reporting, identify the adhesive and the paper stock being used. Indicate the glue temperature and film thickness employed, the atmospheric temperature and humidity at which the paper was conditioned and the test performed, and the size of weights used. List the elapsed time before various bonds were tested, and the corresponding average values found for bond strength (pounds per square inch) and fiber tear (per cent) among the specimens tested. Also indicate the number of identical bond tests contributing to the average values.

As an example, the following results were obtained when the ability of a particular adhesive to laminate a paper stock without heat was being determined by the block-tensile method. The paper was conditioned and the tests, in triplicate, carried out at 73°F. and 50% R. H. A 0.010-in. glue spreader was employed, and weights of a 2-lb. size were used.

Elapsed time	*Strength, lb./sq. in.*	*Tear, %*
20 sec.	0.9 (390 g.)	0
1 min.	2.7 (1240 g.)	2
3 min.	3.4	5
10 min.	4.5	20
24 hr.	5.2	80

Incidentally, the strength and tear variations among those triplicate bond specimens which had been aged 24 hrs. were 4.8 to 5.5 lb. and 60 to 90%, respectively.

The following variations from the usual procedure may be of interest.

To determine the inherent tack of an adhesive, use nonporous adherents. Glass surfaces, for example, may be provided by cementing an inch square cut from a microscope slide to the bottom face of a testing block, and applying a film of the test adhesive to a glass sheet. During comparisons of tack it is especially important that identical thickness of adhesive film and lifting rates of the test blocks be employed.

Inherent tack is here considered as the resistance to cohesive separation of an adhesive film while at its original bond-forming composition. Its measurement, therefore, requires the use of nonabsorbent surfaces which the adhesive being tested will wet readily. Developed tack, on the other hand, may be considered as the changing resistance to separation, either cohesive or adhesive, which an adhesive film exhibits between any specified adherents (such as paper-to-paper or paper-to-glass) from the time the bond is formed until the bond, if broken, would no longer show any re-bonding ability. Developed tack is thus identical with bond strength at least during the earliest stages of bond development.

To determine the quality of mature bonds after soaking, unclamp and remove the blocks from the bonded assemblies unless the blocks themselves are constructed of a material unaffected by water. Then immerse the bonded specimens for the desired period, remove them from the water, carefully replace the blocks, and test as above.

To determine the bonding quality of heat-setting adhesives, prepare the block-tensile bond specimens singly rather than in a group or series, setting each freshly-made assembly on a hot-plate at the desired temperature and weighting it for a suitable period. Variations in the weights being employed, or in the thickness of glue film, allow the effect of these factors on bonding quality to be determined.

Contributed by: R. H. Sams, Philadelphia Quartz Co., Philadelphia, Pa.

RC-268. Speed of Grab Adhesion Test

The following test, devised for evaluating speed-of-set on paper for polyvinyl acetate adhesives, and which can be used for any liquid adhesive, may be considered reliable for semiquantitative comparison testing.

Apparatus

1. Double ring applicator (Fig. 1).
2. Bond paper (16 lb), $8\,^1/_2$ by 11 in. This paper has been arbitrarily selected for general purpose comparison. In the

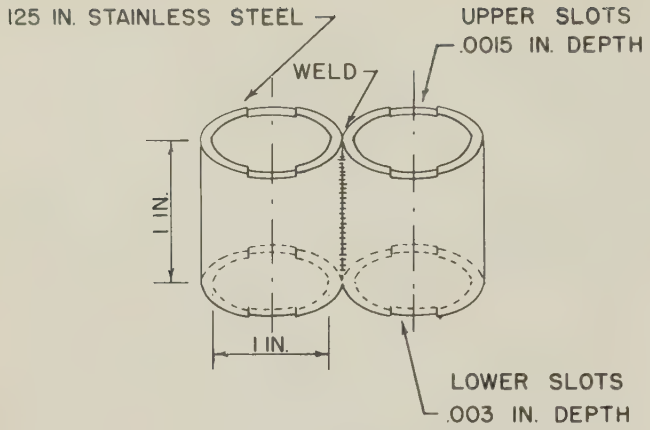


Fig. 1. Double-ring applicator

event the comparison is being conducted for a specific application, it is preferable, of course, to use the type paper involved in the application.

3. Photographic roller, 6-in.
4. Stopwatch.
5. Smooth glass plate.
6. Spatula.

Procedure

Place a sheet of paper under test on the glass plate, positioning the double ring applicator in the center, about 1 in. from the top of the sheet. Place a few drops of the adhesive into one of the double ring applicator reservoirs. Introduce the adhesive to be compared into the other reservoir.

Draw the applicator down quickly with one hand while holding the paper in place by the thumb or forefinger of the other hand. Immediately position a second sheet of paper on top of the first, and draw the photographic roller over the laminate with a light but firm pressure.

Start the stopwatch, and holding the bottom sheet in place on the glass plate with one hand, separate the top sheet by slow peel after predetermined time intervals until fiber tear is noted.

Interpretation

It is important, as previously stated, to note that this test is designed more for comparison testing than for evaluation of a single product; it can, however, be used to determine the speed of fiber tear of a single product simply by using only one reservoir of the applicator.

In determining first time to fiber tear, it will be noted that degree of fiber tear will be an important consideration. Spotty areas of fiber tear will in namy cases appear before complete fiber tear across the total width of the bonded area is obtained. The time for total fiber is taken as tear time.

Contributed by: Morris Bresloff, The Borden Chemical Co., Leominster, Mass.

RC-269. Pin Test of Bond Quality in Corrugated Board

The object of this method is to measure the strength and tearing ability of bonds within corrugated board.

Apparatus

1. A means of cutting rectangular pieces of corrugated board to exact dimensions without crushing the edges. A razor blade in a holder is adequate.

2. A corrugated bond testing fixture, adaptable to A, B, or C-fluted board, which is fixed to a tensile-testing machine that will indicate over a range of about 0 to 150 lb. the force required to separate a board specimen within the fixture. A

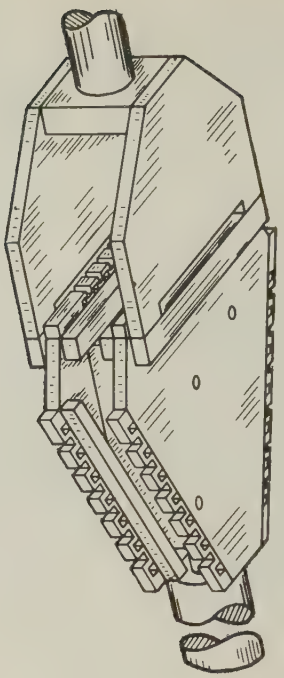


Fig. 1. Corrugated bond testing fixture

suitable flute bond fixture and tensile-testing machine are manufactured by the Thwing-Albert Instrument Co., Penn St. and Pulaski Ave., Philadelphia 44, Pa. The fixture itself can also be adapted by the manufacturer to fit certain other tensile-testing machines.

An advantage of the method is that the quality of any selected bond within corrugated board can be determined, not merely that which happens to be the weakest. Another advantage is that a sizable area of the bond holding a liner to the corrugated medium is being tested, thus contributing to a more significant result than may be obtained when the liner and corrugations are peeled apart.

Procedure

Cut rectangular test specimens from an undamaged area of the corrugated board. For A or C-fluted board a specimen 1.5 in. wide and 14 flutes in length is satisfactory, while a specimen 0.75 in. wide and 14 flutes long is suitable for B-flute.

Adjust the lower grip of the bond testing fixture to accommodate the A, C, or B-fluting of the board. Select the group of 13 metal pins, or rods, appropriate for the size of fluting. (Pins are supplied with the testing fixture.) Adjust the tensile-testing machine so it will separate the grips of the testing fixture at a convenient rate (e.g., 3 in. per min.), and will operate over the lowest range of force sufficient to pull apart the test specimen.

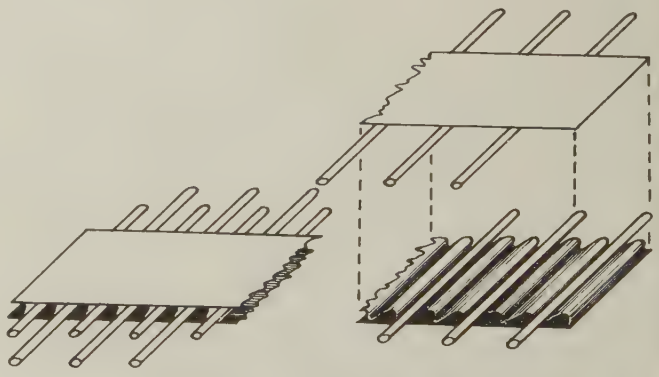


Fig. 2. Bond test specimen, before and after separation

Place a board specimen, with that bonded side which is to be tested facing upward, in the lower grip of the testing fixture. The grip should be in a lowered position while this is done. Insert seven short pins so they pass through alternate flute openings next to the upper face of the specimen and their protruding ends are engaged in the holes of the lower grip. Raise the lower grip, by operating the testing machine, until the slots in the upper grip are level with the specimen. Insert six longer pins so these pass through the remaining flute openings next to the upper face of the board specimen and their protruding ends are engaged in the slots of the upper grip.

Operate the tensile testing machine so the lower grip is lowered steadily. Note the maximum separating force, in pounds, registered by the machine after the upper liner of the specimen has been pulled away from the corrugated medium.

Tensile test at least three supposedly identical board specimens in the same way, testing a larger group if bond quality is obviously spotty or if a strength variation of more than about 8% from the average among a few specimens is found. Lay the separated specimens side by side so their exposed liners and flutes can be observed. Visually estimate, for the specimens as a group, the bond's average fiber-tearing ability, recording this to the nearest 10%—except possibly for a value such as 1% to indicate very slight tear, or 95% to indicate excellent tear along nearly the full length of all flutes. (Good bond strength is not always accompanied by extensive fiber tear.)

In reporting, identify the flute size, the type of construction, and the particular bond of the board being tested. For example, the single-facer (SF) or the double-backer (DB) bond of an A-flute double-face board might be under investigation. Indicate the conditioning or controlled exposure of the board before testing. For example, a "dry" test, without other qualifications may indicate that board specimens were conditioned at least 48 hr. at 73°F. and 50% R. H. and were then tested in that environment. A "wet" test, unless otherwise qualified, might indicate that specimens were conditioned normally and then soaked in tap water at 73°F. for 24 hr., to be tested while wet. For manufacturing guidance, a quick estimate of bond quality after none or only brief conditioning might be desired.

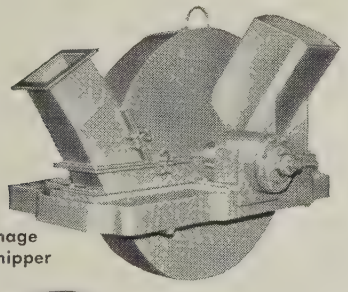
Report the number of bond specimens which were tested identically, then list the values determined for bond strength and tearing ability. The value for bond strength may be reported conveniently in lb. per 12-in. length of flute. This value is calculated by multiplying the measured strength value by the fraction 12/21 for a bond specimen of 1.5 in. by 14-flute dimensions, or by 12/10.5 for a specimen of 0.75 in. by 14-flute size. List the arithmetic average as well as the lowest and highest values revealed in that way by the group of specimens. The fiber-tearing value is simply the percentage estimated when the separated specimens are examined as a group.

As an example, these results were obtained when a sample of C-flute double-face board was tested for conditioned dry bond quality by this method:

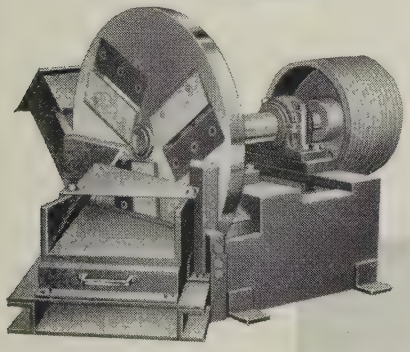
Bond	*Strength measurements, lb./specimen*	*Reported strength, lb./12-in. flute (low–average–high)*	*Tear, %*
SF side	79, 73, 84	42–45–48	20
DB side	87, 88, 98	50–52–56	90

In this instance the bonds were of satisfactory quality, and there was no evidence of decapping, high-and-low flutes, beading, or other difficulties to be reported.

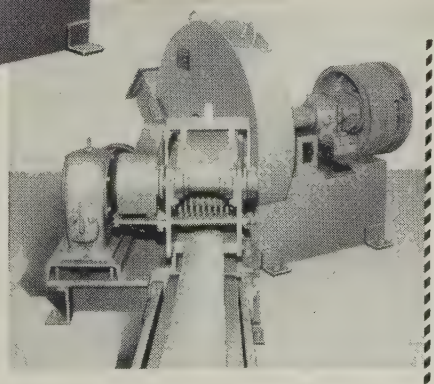
Contributed by R. H. Sams, Philadelphia Quartz Co., Philadelphia 6, Pa.



Carthage 47" Chipper



Carthage 39" Chipper Horizontal Feed



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F

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

New England (Eastern District)

One hundred and twenty members and guests attended the January 12th meeting of the Eastern District, New England Section, TAPPI. Features of the session were: (1) election of officers for 1959 and (2) talk by C. Burke Moore, Dewey & Almy Div., W. R. Grace & Co., on the Sandy Hill "Rotoformer."

Officers for 1959 will be: chairman, Roger Wiewel, Weyerhaeuser Timber Co.; vice-chairman, John W. Wendell, Jr., Tileston & Hollingsworth Co.; secretary, Albert C. Lamoureux, Dennison Mfg. Co.; and treasurer, Phillip Slayton, Monsanto Chemical Co.

Executive Committee: Tom Allar, Virginia Smelting Co.; John Frankevicz, Oxford Paper Co.; Tom Sargent, The Nashua Corp.; E. Whitman Strecker, chairman, New England Section, Esleeck Mfg. Co.; Charles Horch, The Mead Corp., and Dave Lovering, Arthur D. Little Co., Inc.

Charles Horch, The Mead Corp., retiring Eastern District chairman, thanked all for their cooperation during the first year of the District's existence and then turned the meeting over to program chairman, Dave Lovering, Arthur D. Little Co., Inc.

Mr. Lovering introduced C. Bruke Moore, Dewey & Almy Div., W. R. Grace & Co., who discussed the Sandy Hill "Rotoformer." Also on hand to assist him were: George Clink, Sandy Hill's chief development engineer and Jack McCrystale of Sandy Hill, who demonstrated a model "Rotoformer."

By way of background Mr. Lovering mentioned that at the last meeting a speaker discussed the Stevens former, developed at the Erving Paper Mills and as a follow up Mr. Moore had been invited to discuss the "Rotoformer."

Mr. Moore stated that D & A are not commercial papermakers and do not directly own any commercial papermaking equipment. "Our interest," he said, "has come about through our line of impregnated products, including battery separators insoles, shoe welting, and artificial leathers."

The talk was mainly based on laboratory experience with a Rotoformer purchased about 2 years ago for making saturating papers, papers relatively free and open and generally made from long fibered high alpha pulps. The lab Rotoformer is a full-scale machine differing from a production machine only in its relatively narrow 27-in. width.

The speaker said that it is an extremely versatile and well controlled cylinder machine in which machine variables have been brought under control of the papermaker. He added, however, that Sandy Hill likes to avoid the name cylinder machine in describing the Rotoformer as it is different from the conventional cylinder machine in several important ways.

Stating that the Rotoformer is composed of two basic units, a wire-covered cylinder and a headbox, Mr. Moore described in detail, with the use of slides, its entire workings.

It was noted that on the Rotoformer the papermaker has several machine adjustments that he may use to control sheet characteristics. He may vary dilution, the amount of stock recirculated, the position of the pond regulator, vary the position of the first vacuum box, and vary the vacuum on the first box. With these adjustments he may

Charles Horch, The Mead Corp., retiring chairman of the Eastern District of the New England Section, thanks members for helping to make Eastern's first year a success

control the formation of the sheet and the machine direction–cross direction relationship.

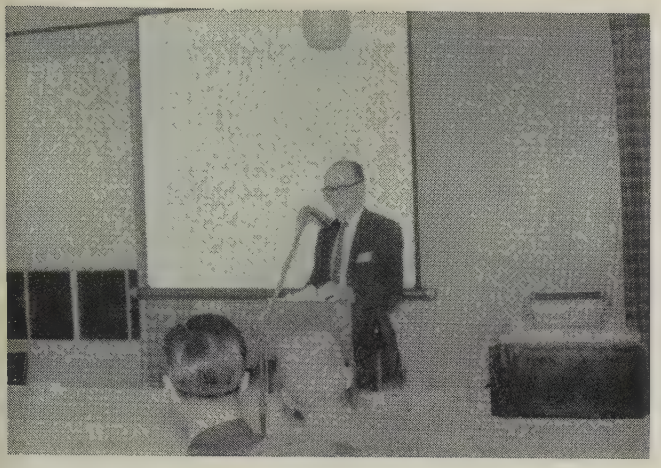
We found, said Mr. Moore, that the sheet generally has the best formation when maximum dilution is used and the pond regulator positioned so that the stock velocity is about equal to surface velocity of the cylinder—probably the same being true with a fourdrinier.

The sheet formed under these conditions is very nearly square, the tensiles in the machine and cross directions being about equal. Sheets have been made with the machine direction tensile about four times the cross direction tensile. Eight to one ratios have been reported, but, said the speaker, "my guess would be that part of this differential was caused by drying conditions."

He stated they were not able to make an oversquare sheet. That is, a sheet stronger in cross direction than in the machine direction.

Mr. Moore explained that at first inspection the forming area on a Rotoformer would appear to be small as compared with fourdriniers. It is little less than a quarter of the circumference; about 18 in. However, drainage on the Rotoformer takes place on the whole 18 in. due to difference in head and the pull of the vacuum, while on the fourdrinier, with perhaps 30 to 40 ft. of wire, drainage primarily takes place at the deflectors and table rolls. The width of the vacuum formed by the contact of the table rolls and the fourdrinier wire have been measured and found to vary from $^1/_4$ to $^1/_2$ in. depending on roll diameter—or it would take a fourdrinier with 40 to 50 table rolls to have the same drainage area as the Rotoformer. An exception to this was noted in the case of a fourdrinier with a steep up-pitched wire on which there is considerable drainage due to head differential.

One important way mentioned by the speaker in which the Rotoformer is different from the fourdrinier is the way in which the formation is controlled. On the fourdrinier the stock comes to the wire through one or more slices which stepwise control the stock velocity. The velocity under each slice is relatively high and tapers off as the stock travels away from the slice. This jet effect under the slices tends toward streakiness in the machine direction which the



C. Burke Moore, Dewey & Almy Div., W. R. Grace & Co., who discussed the Sandy Hill "Rotoformer." A scale model of "Rotoformer" can be seen at right of photo

papermaker tries to correct with the shake. Thus, on a fourdrinier, stated Mr. Moore, a good formation is made by applying a compensation force to overcome the defects caused by the slices.

On the Rotoformer the stock is carefully brought to the wire evenly distributed across the face and the velocity continually controlled throughout the forming area in such a way that a well formed sheet is laid on the wire and held there.

Mr. Moore noted that "depending on the point of view this difference may be both good and bad. The idea of putting a good formation on the wire in the first place rather than trying to overcome a poor formation is fine. However, this means that fibers must be well dispersed so that a good formation will result when the water is drained away. With well beaten fibers it is quite easy to keep the fibers dispersed even at fairly high consistencies, but with long free fibers good dispersion can only be maintained by the use of low consistencies and in some cases the ability to drain the large amount of water needed to keep the fibers dispersed may limit the production.

"Some of our experiments have been made with extremely dilute headbox consistencies—as low as a few hundreths of 1%. More normally we run at consistencies of a few tenths of 1 %."

It was pointed out that the Rotoformer appeared well suited for making heavy sheets with the example given of a successful sheet weighing 900 lb. to the 24 × 36—500 ream. On the other hand sheets as light as 10 lb. to the 24 × 36—500 ream were produced. The speaker added that they required a pickup felt to get the lighter sheet off the wire.

The results of experimental papers made from nylon, dacron, and acrylic fibers also indicated the Rotoformer ideal for synthetic fiber work.

After a most interesting question-and-answer period the meeting was adjourned.

J. F. O'Brien, *Publicity*

Ohio

Ohio TAPPI was treated to an informative talk by Delton Beaulieu at their regular January 8 meeting in Middletown. Mr. Beaulieu, process and product engineer with Kimberly-Clark, spoke on the topic "Some Aspects of Supercalendering," a subject in which the speaker was most qualified.

The speaker elaborated on such pertinent points as stack geometry, roll diameters, and roll filling. In addition, Mr. Beaulieu stressed the effect of moisture application, the effects of calender speed and control of stock temperature.

Delton Beaulieu addressing the Ohio Section of TAPPI

B. M. Beaulieu, Maxwell Paper Co., Franklin, Ohio, was program chairman for the evening.

The February meeting for Ohio TAPPI will feature Wilfred Gallay of the E. B. Eddy Co., speaking on the subject "Rheology of Paper." This meeting will be held Tuesday, February 10, at the Manchester Hotel in Middletown.

Frank L. Cessna, *Recording Secretary*

Indiana District

There were 26 members and one guest present at the Jan. 20, 1959 meeting. Unfavorable weather conditions made it impossible for many to attend.

In the absence of Harris O. Ware, Charles Eberly presided. The minutes of the Dec. 16, 1958, meeting were read. Cushing Roth, treasurer, submitted his report showing a current balance of $241.92. Both the minutes and the treasurer's report were unanimously approved.

Mr. Eberly announced that the February 17 meeting would be in Hartford City, Ind., and would include a plant tour of the Hartford City Paper Co., from 2 to 5 p.m. with cocktails and dinner at the Moose Lodge, 112 South Jefferson St. in Hartford City starting at 5:00 p.m. All times Central Standard.

There was no new business.

Mr. Eberly then introduced the guest speaker, Edward J. Heiser of the Coatings Technical Service Dept. of the Dow Chemical Co., Midland, Mich. Mr. Heiser gave a very informative talk illustrated with slides covering the various coating machines generally in use in the paper industry.

The reasons for coating paper, the function of pigments and the purpose and characteristics of binders were discussed. Mr. Heiser then spoke briefly on each of the following coating processes: brush coating, roll coating, air brush coating Kimberly-Clark Mead 1-side coating, Kimberly-Clark Mead 2-side coating, Consolidated Machine coating, Combined Locks coating, offset gravure machine coating, Champion machine coating, Rice Barton trailing knife coating, and size press coating.

A lively question-and-answer period followed and the meeting was adjourned at 9:45 p.m.

John S. Sullivan, *Secretary*

Kalamazoo Valley

The annual "Papermakers Get Together," sponsored jointly by the Kalamazoo Valley Section of TAPPI and the Michigan Division of the Paper Industry Management Association was held at the Harris Hotel, Kalamazoo, Jan. 15, 1959. Over 400 paper industry men from all parts of Michigan and several other states listened to the main address

by Albert E. Bachmann, president of Missiquoi Corp., Sheldon Springs, Va.

Robert deS. Couch, manager, carton and container division of the General Foods Corp., Battle Creek, acted as toastmaster for the evening. Others on the program included E. E. Stephenson, Sutherland Paper Co., chairman of Kalamazoo TAPPI; W. O. Kroeschell, Michigan Carton Co., program chairman of TAPPI; Ward D. Harrison, president of Allied Paper Corp., National president of TAPPI; Philip Nethercut, New York, Assistant Executive Secretary, TAPPI; A. H. Nadelman, chairman Western Michigan University's paper technology department; Bert H. Cooper, Kalamazoo Paper Co., president of the Paper Foundation, Inc.; Howard E. Wehr, The Mead Corp., National president of PIMA; Harry Weston, New York National secretary-treasurer of PIMA; Harold Annis, Rumford, Me., National vice-president elect of TAPPI and Ray Barton, Hamilton Paper Co.

Mr. Bachmann in his after dinner address called for closer understanding between the technical and practical men in the paper industry. Their jobs should compliment each other in solving hundreds of problems. The technical man's value lies in discovering new processes and proving their value by controlled experimentation while the practical man's experience provides judgment on their value in production work.

To work together effectively in close cooperative relationship requires an understanding on the part of the technical man and the practical man of each other's knowledge and intellectual and psychological strengths. Through such an appreciation of each other's values they each will be eager to learn from the other so that the desirability of having the authority of knowledge and ability prevail in all situations.

P. Dean Graham, Jr., *Secretary*

Lake States

The second meeting of the 1958–59 Lake States TAPPI program was held on Nov. 11, 1958, at Wausau, Wis. The theme of the meeting was "Controlled pH Sulphite Pulping." Mill visits were conducted through the research laboratories and the Rothschild mill of the Marathon Div., American Can Co., and the Wausau Paper Mills, Brokaw, Wis. Following the visits, the members assembled at

Back row: R. C. Crain, Rhinelander Paper Co., Rhinelander, Wis.; W. J. Bublitz, Kimberly-Clark Corp., Neenah, Wis.; G. H. Tomlinson II, Howard Smith Paper Mills, Ltd., Cornwall, Ont.; Don MacLaurin, The Institute of Paper Chemistry, Appleton, Wis. Front row: J. S. Buchanan, Nekoosa-Edwards Paper Co., Port Edwards Wis.; E. H. Kennedy, Combustion Engineering, Inc., New York, N. Y.; T. G. Sheridan, Howard Smith Paper Mills, Ltd , Cornwall, Ont.; L. T. Welch, Howard Smith Paper Mills, Ltd., Cornwall, Ont.; and J. W. McKinney, Abitibi Power and Paper Co., Sault Ste. Marie, Ont.

Panel Discussion: Messrs. Buchanan, Tomlinson, McKinney, and MacLaurin

the Wausau Elks Club for the seminar. The guest speakers and their topics:

"The Arbisco Process," J. W. McKinney, Abitibi Power and Paper Co., Central Research and Development Division, Sault Ste. Marie, Ont.

"Mill Scale Trial Run with the Magnefite Process," L. T. Welch, T. G. Sheridan, and G. H. Tomlinson II, Howard Smith Paper Mills, Ltd., Cornwall, Ont.

"The Bisulphite-Soda Process," J. S. Buchanan and E. H. Kennedy, of Nekoosa Edwards Paper Co., Port Edwards, Wis., and Combustion Engineering, Inc., New York, N. Y., respectively. (To be published in *Tappi* at a later date.)

Following the talks, the social hour and dinner took place. A panel discussion, including questions from the audience, was conducted after the dinner. Don MacLaurin of The Institute of Paper Chemistry was the moderator for the session, which drew many interesting and occasionally spirited remarks from the group and panel.

Due to the pertinence of the theme, the fact that the Lake States paper industries depend so heavily on sulphite pulp, the meeting was well attended, and the interest was high. Over 200 members attended the afternoon talks, and about 180 remained for dinner.

Walter J. Bublitz, *Chairman*

A Mill Scale Trial with the Magnefite Process

L. T. Welch, T. G. Sheridan, and G. H. Tomlinson II

The sulphite mill of Howard Smith Paper Mills in Cornwall was placed on extended trial operation with the magnefite process which lasted for approximately 4 months. The process was operated without heat and chemical recovery inasmuch as such facilities are not available at the mill. The chief purpose of the test was to establish the suitability of softwoods such as pine and tamarack and of hardwoods for this process. This possibility, together with improved strength and yield had been indicated in previous laboratory studies reported at the Canadian Pulp and Paper Association in January, 1958.

A system was installed for producing the cooling acid which consists of a solution of magnesium bisulphite, free of excess sulphur dioxide. The gas from the sulphur burner was contacted at the throat of a venturi with a spray of recycled solution of liquor to which magnesium hydroxide had been added. Two such venturis were used and the final liquor, which was produced at 60°C., contained 2.0% combined SO_2 and had a pH of about 3.7. The liquor composition at the secondary unit was maintained at about 1% combined SO_2 and at a higher pH of about 5.7.

The chips were presteamed during their introduction to

the digester, then the liquor was run in and recycled for a short time to the accumulator following which a hydrostatic pressure of 96 p.s.i. was imposed for 20 min. while the digester was being heated. A portion of the liquor was withdrawn and the pressure was maintained at about 5 p.s.i. above the vapor pressure of water as the digester was further heated. The maximum temperature of 166°C was held for $1^3/_4$ hours. The pressure was relieved to about 50 p.s.i. and then the digester was blown.

It was found desirable to control the pulp to a higher chlorine demand than with the regular process. This resulted in a higher bleached yield of pulp. With spruce this amounted to 6.8% increased yield when the additional bleach requirement amounted to 40 lb. per air-dry ton. The burst and tear values of the unbleached spruce pulp were 118 and 111%, respectively, of the regular pulp. The pulp from sawmill pine chips and from mixed softwoods was not so strong as magnefite spruce but slightly stronger than regular spruce sulphite. Hardwood magnefite showed burst and tear values that were 111 and 124% of those obtained with acid sulphite pulps from the same wood. Due to limitations in the mill bleach plant some loss in strength occurred when this pulp was bleached to high brightness. This did not occur when the pulp was bleached to medium brightness, nor when bleached in the lab under milder conditions to high brightness. It was therefore concluded that changes in the bleach plant would result in a considerable further strength improvement. However, the pulp as produced was found satisfactory for a very wide range of fine papers.

This first run indicated that local woods could be used to give satisfactory pulps although chemical costs were high when operating without recovery. These chemical costs, and the energy cost, can be reduced to a very low value by installation of the relatively simple magnesia base recovery system which would place the whole process on a highly efficient basis.

Details with regard to acid make-up, the digestion process, various problems encountered, and the advantages shown were presented.

The Arbisco Process

J. W. McKinney

Experiments at the Central Research and Development Division of Abitibi Power & Paper Co. have led to the development of a pulping process, which uses a liquor containing pure sodium bisulphite. Analysis by the Palmrose method shows equal parts of "free" and "combined" SO_2, meaning that all of the SO_2 is in the form of $NaHSO_3$, and only minor amounts of gas are evolved during a cook. At conventional yields bright pulps are produced with low tailings; at higher yields, the soft chips refine with low power, especially for hardwoods, and brightness is well maintained. The pulps are bulky and contain slightly more pentosans than normal acid sulphite, but decidedly less than neutral sulphite.

With spruce the strength is high, comparable to kraft in burst while somewhat lower in tear, but the pulps beat like sulphite rather than kraft. Jack pine responds well to this liquor and excellent results are also obtained from hardwoods, although the strength varies with species. Using poplar and birch, the unbleached strength is higher than for an NSSC cook, but no comparable increase occurs on bleaching. However, the Arbisco process is suitable for the cooking of mixtures, not only of hardwoods, but also of softwoods with hardwoods, developing the strength due to each component. No strength is lost in bleaching with a three-step sequence, and the chlorine demand depends on the permanganate number and in turn on the lignin content, just as with acid sulphite pulp.

Extensive mill trials have shown that the Arbisco process lends itself to mill operation with direct cooking at high yields, and gives excellent results for newsprint, producing a cleaner sheet than high-yield sulphite. Substantial additions of jack pine and hardwoods can be made without any deterioration in the paper. Tests on fully-cooked pulps in a fine paper mill have shown that arbisol pulps bleach readily without loss in strength and mix well with other pulps for satisfactory machine operation, and the anticipated increases in strength are fully confirmed in the papers.

This process would be advantageous for any sulphite mill desiring a pulp of higher strength or utilization of hardwoods without loss in pulp strength, while avoiding too drastic changes in furnish. Capital costs for a changeover would be moderate.

The Sivola Sulphite Cooking and Recovery Process

J. S. Buchanan and E. H. Kennedy

This paper describes briefly the history and background of the process and then continues with paper mill laboratory results of cooking various species of wood by single and multistage digestions and a description of the chemical conversion process.

Three pulp and paper research laboratories, one in Finland, one in Sweden, and one in this country, have made detailed studies of this cooking process both on a laboratory and a plant digester scale. The research group of the Nekoosa-Edwards Paper Co. has concentrated on pulping Lake States hardwoods, including mixed oak, aspen, birch, and maple using the two-stage (bisulphite-soda) digestion. Jack pine pulping by this process was also investigated.

This cooking process consists of a sodium bisulphite first stage followed by an alkaline stage without interrupting cooking in the same vessel. The major portion of delignification is accomplished in the first stage which is a true bisulphite cook (pH = 4.0).

Sodium carbonate is injected into the digester for the second stage to produce a pH in the range of 7.5 to 9.5. By adjusting the relative time of the two cooking stages, the temperature, and the pH of the alkaline stage, a wide range of pulp types can be prepared from all of the wood species investigated.

The well established advantages of high combined sulphur dioxide (or bisulphite) pulping are combined with the effects of an alkaline cook to yield a very versatile process whereby pulps can be made having strength comparable to kraft, but yet are easy bleaching—like conventional sulphite.

Since the literature contains very little and some contradictory work on the effects of thiosulphate in soluble base cooking liquor on pulp properties, a study was made with aspen to ascertain these effects, their degree of damage, and the quantities of thiosulphate that may be tolerated in the recovered cooking liquors. It was shown that small quantities of thiosulphate in high free sulphur dioxide pulping causes darkened pulps and increased bleach demand. Thiosulphate present during high combined sulphur dioxide pulping is less serious and larger amounts can be tolerated.

In this two-stage cook, thiosulphate can be present at concentrations up to 8% $Na_2S_2O_3$ based on O.D. wood (30% of cooking liquor sodium as $Na_2S_2O_3$) without undesirable effects. It has been shown that thiosulphate can be classified as an active delignifying agent under proper conditions.

The Sivola conversion process was described in detail with flow diagrams which show the available chemical streams in and out of the system and the functions of the component parts. Flow diagrams also show the possibilities of using the recovery process for mixed spent liquors involving single-stage bisulphite plus sulphur dioxide or single-stage bisulphite or two-stage bisulphite-soda with kraft, soda, or NSSC digestions.

Gulf Coast District

The following papers were presented at the meeting of the Gulf Coast District in Pensacola, Fla., Nov. 21, 1958.

The Debarking of Hardwood

T. N. Baker

THE subject of hardwood debarking raises several questions and a discussion of these and some of the possible answers is the subject of this paper—(1) why debark hardwood? (2) what is hardwood? (3) is hardwood in use for pulp today? (4) how is hardwood currently debarked? (5) why is hardwood more difficult to debark than softwood? and (6) what is the best way to debark hardwood?

WHY DEBARK HARDWOOD?

This question has several valid answers coming from several sources. The forester in the South, who is faced with a hardwood stand composing more than half the available wood volume, wants hardwood debarked efficiently to increase its use in papermaking. Harvesting hardwood at a rate equal to or greater than its growth would stop or reverse the natural, but undesirable, conversion of pine stands to hardwood stands. The faster growth rate of softwood, often more than twice as fast as hardwood, is a prime factor in the forester's mind as a maximum production in cords per acre per year is his objective.

Hardwood industries such as lumber and veneer want an efficient means of debarking hardwood to reduce their costs of knives and saws and to render their wood residue salable as pulpwood chips.

The wood procurement personnel in the paper industry want to see hardwood debarked efficiently as an increase in its use would open a source of lower cost fiber to offset the rising cost of softwood. One prime factor serving to make this a lower cost fiber is its location in relation to the paper mills, these hardwood stands having been passed as each mill reached further out for softwood.

WHAT IS HARDWOOD?

A comparison or differentiation between softwood and hardwood will serve best to define hardwood for the purpose of this discussion. Hardwood is an angeosperm, a dicotyledon, a broad-leaf tree, is normally deciduous in the temperate zone and is a porous wood. Softwood is a gymnosperm of the order coniferales, having a needle-shaped leaf, is usually an evergreen and is nonporous. Generalizing these definitions for simplicity, a hardwood is a broad-leaf tree and the softwoods are cone bearers.

IS HARDWOOD IN USE TODAY?

The South is using hardwood for pulp at an approximate rate of $2^1/_4$ million cords per year. This annual consumption of $2^1/_4$ million cords represents approximately 12% of the pulpwood consumed in this area. Comparing this use with the estimate that 56% of the wood volume in the South is hardwood, it is evident that the rate of use must be increased to maintain an equilibrium between hardwood and softwood in spite of the more rapid softwood growth.

Approximately $2^1/_2$% of the hardwood consumed is delivered in chip form. Percentage wise this volume is insignificant, but the rate at which this source is increasing is astounding, approximately 400% increase during the first nine months of 1958. This increase in the use of chips as a source of hardwood fiber has come at a time when the over-all use of hardwood, round wood sources, and chip sources combined, has remained constant.

T. N. BAKER, St. Regis Paper Co., Pensacola, Fla.

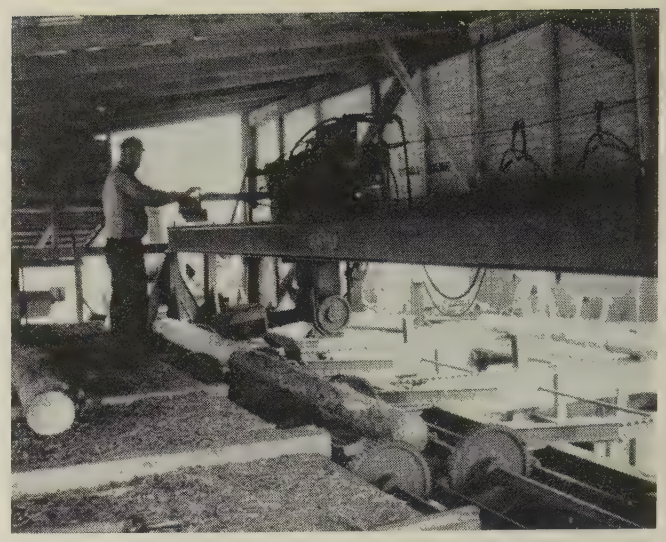


Fig. 1. Little Beaver barker

HOW IS HARDWOOD BARKED TODAY?

Approximately 35% of the $2^1/_4$ million cords of hardwood to be used in the South this year is consumed by mills producing semichemical corrugating board. Due to the latitude in bark content of chips prepared for this product, some of the using mills make no attempt at bark removal; others attempt to remove it all and there are many compromises between these extremes. Approximately 5% of the $2^1/_4$ million cords is mechanically debarked, using debarkers other than the drum. The remainder of the barking is done by drum debarkers. The increase in the amount of purchased hardwood chips as a source of hardwood fiber is decreasing the amount of drum peeled hardwood. Furthermore, the wide use of drum barkers on hardwood does not necessarily indicate this to be the most desirable method. Drum installations in woodyards in the South have customarily been sized to supply the mill when operating on softwood at a rate of 20 to 30 cords per hr. and, therefore, when operating on hardwood this rate is maintained with a material reduction in quality of debarking. Drum debarking of hardwood can be quite effective when the limitations are recognized. The other types of mechanical debarkers used in the South vary widely, but the primary difference between them and the drum is the single stick feed. Following are descriptions

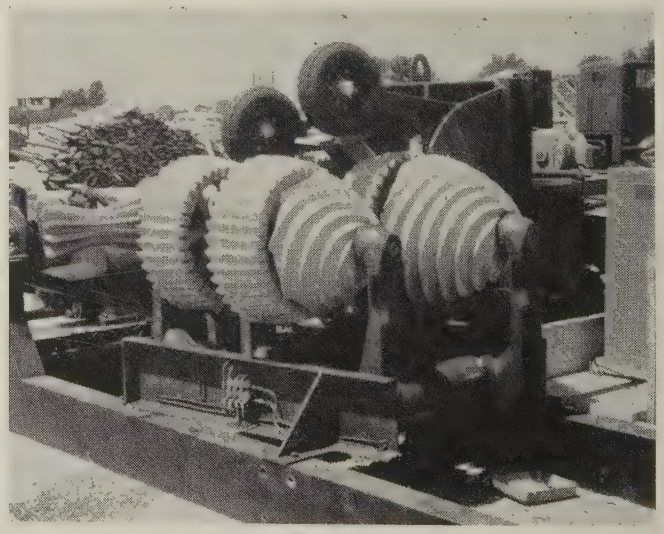


Fig. 2. Coon Hound barker

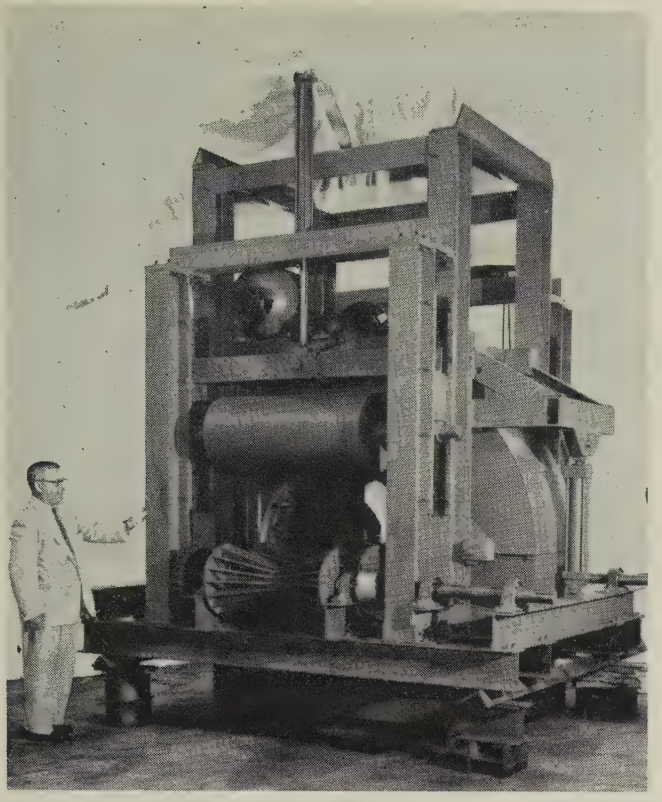


Fig. 3. Mullis log skinner

some of these debarkers used in this area. The omission of any particular machine is not intended to infer inadequacy.

The "Little Beaver" debarker (Fig. 1) built by Jackson Industries, Inc., of Birmingham, Ala., is a rosser head machine which revolves the log. These type debarkers are manufactured primarily for use where the volume of wood to be handled is small and where the wood can be well trimmed and reasonably straight. Each log is turned into the front of the machine in a cross feed method and rolled out at the rear in a similar manner. The rosser head is lowered onto the log and fed along the revolving log by an operator who moves along with the rosser head. The quality of work and the amount of fiber loss is dependent upon the skill of the operator. The length of frame in these machines is selected to suit the length of the longest log to be peeled. Some of the other debarkers using these principles are as follows: Fulghum Industries, Hansel Engineering, Hosmer Machine and Lumber Co.,

Fig. 4. Nicholson roto barker

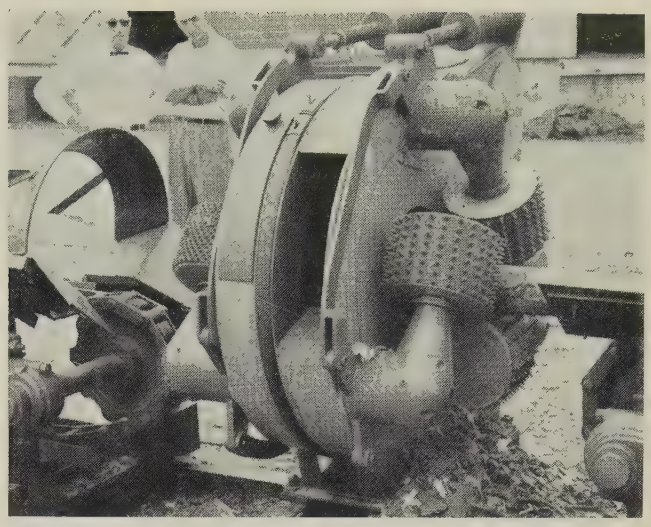


Fig. 5. Cambio barker

Soderhamn Machine Manufacturing Co., and the White River Machine Co. Inc. Eaton log barkers.

The "Coon Hound" debarker (Fig. 2) manufactured by Nicholson Manufacturing Co. of Auburn, Wash., also turns the log but it does not incorporate a rosser head. Logs are fed through this debarker endwise in a spiraling motion. The logs are held on the trunions by two air operated pneumatic hold-down rolls. Between these two hold-downs is an air operated scraper tool whose blunt edge is used for bark removal. The first set of trunions loosen the bark and remove most of it due to the pressure applied by the hold-down. This machine is also quite limited in production and operates best on straight wood.

The "Mullis Log Skinner" (Fig. 3) manufactured by Carl W. Mullis Engineering and Manufacturing Co. of Lancaster, S. C. is a ring-type debarker using air loaded tools. The logs are fed endwise through a revolving ring. Barking is performed by four air loaded scraper arms mounted in and rotating with the ring. A unique feature of this machine is that the air reserve is contained within the ring and operates without a revolving air seal. The reservoir is refilled while the machine is not in use and affords several hours of operation without refilling. The size of this debarker, as well as that of other ring debarkers, designates the maximum diameter log that can be peeled. Mullis currently manufactures three size machines; 26, 30, and 36-in.

The Nicholson Rotobarker (Fig. 4) built by Nicholson Manufacturing Co. of Auburn, Wash., is a ring-type debarker with air operated tools. This machine has a rotating air

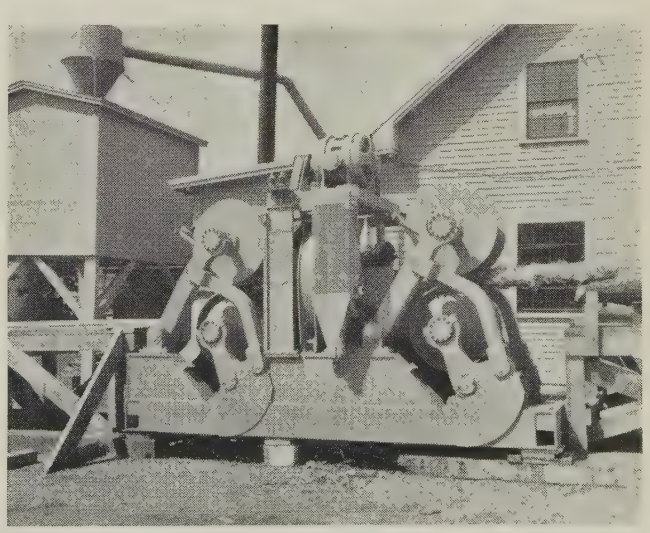


Fig. 6. Impco S-20 barker

seal which affords operator control of tool pressure and tool release during operation. These machines are available in the following sizes: 26, 34, 42, 60, and 72-in. Some of these machines can be equipped with high lift or side moving ring sections that will pass oversize logs without peeling. Controls are also available for near automatic operation.

The Cambio Debarker (Fig. 5) manufactured by Soderhamn Machine Manufacturing Co. of Talladega, Ala., is a ring-type debarker whose tool pressure is normally preset and is maintained by the tensioning of rubber bands. This machine features a self opening feed which centers the log and propels it between the self-opening tools. This machine is capable of 150 f.p.m. feed speed and requires no operator adjustment except stops necessitated by log size or shape. The "Cambio" is available in sizes and follows: 14, 21, 26, and 43-in. The largest size is equipped with an external control of tool pressure that affords adjustments during operation.

The Impco S-20 Debarker (Fig. 6) manufactured by The Improved Machinery Co. of Nashua, N. H. is also a ring-type debarker having preset tool pressure and self-opening feed and tools. The tool pressure is provided by the twisting of helical springs. This machine requires little attention during operation and will accommodate a log up to 21 in. in diameter.

WHY IS HARDWOOD MORE DIFFICULT TO DEBARK THAN SOFTWOOD?

The debarking of hardwood is considerably more difficult than the debarking of softwood, a characteristic which probably arises from several points. The fact that hardwood is normally deciduous and softwood normally evergreen indicates a longer and more pronounced dormant period in hardwood. During this dormant period the cambium, the normal point of cleavage in barking, dries and tightens its bond with the wood and bark. A fracture at this time is more apt to occur within the bark and result in improper barking.

The structure of the bark on hardwoods varies over a wider range than that of softwood, from the rough thick bark to the thin smooth bark. The most difficult of these to debark are the thin barked trees which afford less resistance to the rubbing action of a barker. A third source of the hardwood barking problem is attributable to the shape of the stems. Hardwood pulpwood is characterized by large protruding knots, crooked stems and often large deep veins at the base. Each of these irregularities offers resistance to the barking action which results in imperfect cleaning.

WHAT IS THE BEST WAY TO DEBARK HARDWOOD?

The foregoing has all been prelude, for the hope of an adequate answer to this question has motivated this and many other quests for barking knowledge. Applying the available technology and equipment to this problem, the following scheme is offered as a workable but imperfect solution:

Hardwood should be debarked as soon after cutting as possible to avoid the problem of cambium shrinkage in drying. This precludes any rough hardwood storage. The wood should be harvested in as long a piece as is practical and 7 ft. 6 in. is suggested as a minimum. These longer bolt lengths facilitate the feeding of the recommended barker. A ring-type debarker should be used and such a machine should incorporate self-opening feed and instantaneously variable tool pressure. Hardwood inventories, were required, should be maintained in the form of clean wood and perhaps even clean ships which would afford stream flow handling.

A truly adequate answer to hardwood debarking is unlikely to be found until our technology of barking is vastly improved. Barking, as used here, does not refer to any specific method or principle; it is intended in the broadest sense, the separation of wood and bark. Such a separation might be effected with whole trees, logs, pulpwood bolts, or even chips or in some other form not envisioned here. The research required to improve this technology can best be conducted by you of TAPPI and it is hoped that being reminded of this problem, each of you will pursue it with your special skills and educations to speed the day when barking will not be the number one problem of wood preparation.

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Presented at the meeting of the Gulf Coast District of TAPPI held in Pensacola, Fla., Nov. 21, 1958.

Control of Industrial Waste

Vincent D. Patton

BEFORE one starts talking about the control of industrial waste, it might be wise to stop and consider at least one question. Why should industrial waste be controlled? The basic answer to this question can be given in a few words. The main reason for controls is to prevent undue interference with the rights of others. I believe it can be said that one of the basic concepts of the American way of life is that everyone should have the freedom to earn an honest living and enjoy the fruits of his labors without unnecessary annoyance, subject to the normal restrictions of community law and life. By this statement, I do not intend to imply that if anyone of us happens to dislike a neighbor, we are free to take drastic action against him on our own responsibility. However, on the other hand, we have the right to expect that everyone in the community be a good neighbor. The actions of a person affect greater number of people as the population density of an area increases. I doubt very much if anyone will fail to agree that the population of this region has increased considerably in the past several years and the population growth appears to be following the same trend line.

Coupled with this population increase, we have witnessed an upsurge in the South's industrial development. This has produced a higher per capita income which has brought about a higher standard of living for many of the people of the area.

This increase in population, industrial growth, and standard of living has also created a greater necessity to insure that we do not interfere with the rights and pleasures of others.

In consideration of these factors, we may note that the recreational demands of the population have increased very considerably. The fishing industry and the boating industry both bear strong testimony to the interested pursuit of recreational activities by many people. In addition to fishing and boating, there are also other sports and activities such as water skiing, harvesting of shellfish, and similar activities and functions. In some cases, you will probably find that several people enjoy several or all of these activities.

In addition to the recreational functions, the aesthetic aspects of our environment are another reason for control.

VINCENT D. PATTON, Sanitary Engineer, Florida State Board of Health, Bureau of Sanitary Engineering, Jacksonville, Fla.

Everyone likes to have our surroundings as comfortable and pleasant as possible.

In addition to the recreational activities mentioned previously, we may also include those of certain other facets of our everyday life. Undoubtedly, you will find that the use of water for drinking purposes ranks first in the over-all classification of water supply sources. In addition, our waters can be used for commercial fishing, harvesting of shellfish, navigation, irrigation for agricultural purposes and, last but not least, to meet the process requirements of industry.

If we explore the latter aspect further, we will probably find that one strong reason for control is that industry needs to control the loss of materials and products to maintain the balance sheet in proper conditions. An example of this is the loss of chemicals in the waste water stream in a pulp and paper mill. If you should allow an unnecessary high amount of, let us say, caustic soda ash, or other material that may be in use, to be lost, the cost of your product will be increased by such losses. This will either reduce the margin of profit or else result in an increased price to the consumer, either of which placed the company in a poorer competitive position.

Another item which I should like to touch on is that of water consumption. I do not think anyone will argue the point that water is one of the essential elements in the production of pulp and paper. Here, again, we have two aspects of the problem. In certain localities the demands for water are beginning to equal or approach the available sources of supply.

In evaluating the cost picture of industrial waste control, I think it is only reasonable to say that the pressures for such control have increased and may be expected to increase still further as our population continues to grow in the vicinity of industrial plants. Continuation of present trends insofar as labor and material costs are concerned will probably also result in greater demand for minimum process cost insofar as attainable.

Now, let us look a little further. Basically there are two solutions to the problem of control. One—treat everything that leaves your mill. Two—make necessary changes within the plant in your process to reduce the losses to an absolute minimum, with subsequent necessary treatment.

If we regress slightly at this point, I believe that good control starts before a pulp and paper mill is constructed. By this I mean, satisfactory plant location and all the factors that go into this problem. After the site has been selected, I believe it is wise for management to either make or have made a background study of the receiving waters. In many cases this has not been done and consequently management has sometimes found themselves in a slightly embarrassing situation that could have been avoided if they had made such a study and could show what, if any, changes occurred. In some cases, today, this is done and proves to be very valuable data.

Now let us consider in an economic sense what happens in each of the two courses of treatment mentioned previously. At times we find the first approach, and as a usual rule, a rather expensive solution, especially in view of the large volume of waste water which is produced from today's modern pulp and paper mills. When one starts designing a treatment system to handle, say, 5,000,000 g.p.d. or more of waste water, you will invariably find that the company is faced with a requirement for an outlay of a large sum of capital. In addition, you will also find, as a rule, that you will be required to spend a considerable amount of money each year for operating expenses. One cannot expect any tangible returns in dollars and cents from such a plant. However, there may be intangible or indirect profits. If you will bear with me, I will attempt to expand on this a little bit later.

There has been a tendency by some people to question the value of this second approach. Apparently, some persons seem to feel that if the reductions in the waste produced by the plant are built in or designed by the designing engineer and the operating personnel becomes somewhat negligent, it may result in losses of large amounts of material which completely overloads the waste treatment facility. However, this depends entirely upon the human element and is something which I doubt that we shall ever escape in that our troubles are caused by people and they can be eliminated by people.

Let us assume that the problem of waste treatment is approached from the second avenue in that we shall attempt to reduce in-plant losses as much as possible. This will normally be the most lucrative route which will accomplish our objective; that is—reduce the pollutional load on the receiving waters to a satisfactory level and also at the same time permit lower process cost through lower water usage and lower chemical losses. It is obvious that if we reduce the pounds of make-up process chemicals and reduce the amount of make-up water required, we will decrease the process cost and any remaining waste that must be treated will be of a much lower volume and strength and therefore require a lesser expenditure of capital for construction of the treatment facilities. However, we should not fall into the error of thinking that a reduction in waste volume means the waste strength has decreased.

In addition, I think one should also consider that the lower demands for water may permit postponement for a considerable period of time, or even indefinitely, expansion of water supply sources. In considering treatment and control of waste, there are several methods which are available, although some are more applicable than others and please bear in mind, there is no tailor made solution that will fit every installation. Methods of treatment may utilize equipment used to treat domestic sewage, such as the trickling filter or activated sludge. These two methods have been tested and used and it appears that activated sludge may have some advantages. In either case the initial outlay as well as the subsequent operational cost may be rather high for a given volume of waste water.

One possible solution which might be used in the use of waste water to irrigate woodlands. It is my own personal feelings that this is worth some investigation since it gives promise of possibly disposing of the waste as well as providing a more rapid growth of the timber necessary as a raw material. In some cases, mills have utilized primary clarifiers similar to those used in treatment of domestic sewage. Here, again, one of the main items is the cost of construction. This has been mitigated to some degree by use of stabilized earth walls and floors with installation of necessary equipment.

In addition to the above mentioned methods, there has been considerable use of oxidation ponds or settling basins or whatever name you may desire to use. These have the advantage of a fairly low capital expenditure in relation to some of the other methods and can provide a considerable degree of treatment. These in turn may be modified by use of aeration or various arrangements in an attempt to give an increased degree of treatment. I think it is wise to bear in mind that the objective of any of these methods is to reduce the pollutional load on the receiving waters such that they may serve their useful functions in a normal manner without creating undue hardship on others.

In closing, I should like to mention one item that has been of concern to me for some time. It is a subject on which I feel that many companies, not only pulp and paper, but others as well, have been rather negligent in their duties. Here I refer to the fact that if your company should be unlucky enough to have the misfortune to cause a pollution problem, you may be almost certain that you will be in the limelight of the public and your misdoings and misdeeds, and

misfortunes will be shouted from the housetops by all newspapers. You have all heard the saying, "There is no news like good news," but sometimes I wonder if that shouldn't be paraphrased in that bad news seems to make the headlines much more quickly than good news. Therefore, I would suggest that all of you strongly consider the possibility of improving your public relations and attempt to improve your company's standing with the general public in your area. As I said before, if you are unfortunate enough to be brought into the public eye due to some accident or other reason, you may be certain that you will be given full publicity. Therefore, let me suggest that if you carry out any kind of work which will assist in improving your receiving water, surrounding territory, or the air, don't be too hesitant about blowing your own bugle and letting the general public know what the story is. This probably seems like a very simple and straightforward point, but I have noticed in the past when I asked several plant managers, where they have taken action to improve the receiving waters, either in-plant or by installation of waste treatment facilities which were needed, "Have you attempted to inform the public by various means of the action you have taken and how much money you have spent, and what you are doing in order to be a better citizen of the community?" the answer is "no" in a surprising numbers of cases. So I again urge you to let the other citizens of the community know that you are not living in your own little world caring little for the influence your operations may have on others.

Presented at the meeting of the Gulf Coast District of TAPPI held in Pensacola, Fla., Nov. 21, 1958.

Virginia-Carolina

The following paper was presented at the meeting of the Virginia-Carolina Section of TAPPI held in Richmond, Va., Dec. 5, 1958.

Continuous Flow Methods for Cold Soda Semichemical and Rapid Agricultural Fiber Pulping

J. N. McGovern

Continuous flow methods for pulping of wood were first introduced about 15 years ago. Since that time there have been a number of successful installations for producing coarse fiber, semichemical, and kraft pulps. The number of continuous pulp mills and the corresponding productive capacity are still growing and it is generally viewed in the industry that there is an established trend in the direction of increasing applications of continuous pulping for new mills as well as for possible conversion of existing mills.

Recent developments in continuous pulping have been along the lines of improvements and innovations in processing methods and equipment on the one hand, and of applications to different pulping processes and fibrous raw materials on the other. The developments in processing methods for present applications appear in the literature as they are perfected and are not considered in this report.

However, a discussion of the latest applications of continuous methods to new processes, namely, to (1) the treating stage of the cold soda semichemical process and (2) the rapid pulping of agricultural fibers, was believed to be timely. Therefore, there are included in this report descriptions and evaluations of the continuous methods for the treating stage of the cold soda process and the rapid pulping of bagasse, wheat, and rice straw and cotton linters. In determining whether these two processes are basically suitable for continuous operations, certain measures of applicability used in general chemical engineering practice are employed. These measures are outlined briefly.

It is noted that there has been a small production for a number of years of straw and sugarcane bagasse pulps by the Celdecor continuous pulping process, which is not classed as a rapid pulping method.

J. N. McGovern, Parsons & Whittemore, Inc., New York, N. Y.

Table I. Measures of Applicability of a Continuous Process

A.	A Continuous Process Is Doubtful If
1.	A slow reaction must go to completion
2.	Volumes are small or times are long or both
3.	Operation is intermittent or an 8-hr. day is used
4.	Complex temperature or pressure schedules are needed
5.	Undesirable bacterial action takes place
B.	A Continuous Operation Should Be Considered If
1.	Reactions are not required to be complete
2.	Volumes are large or times are short (or both)
3.	Materials are of low intrinsic value
4.	Countercurrent operation is feasible
5.	An excess of one reactant is allowable
6.	Precipitation or extraction is involved
7.	Operation is for 24 hr.
8.	Testing is not complicated
9.	Batch charging and discharging are lengthy
10.	Complex schedules are not needed

MEASURES OF APPLICABILITY OF CONTINUOUS FLOW METHODS

A continuous flow process is usually defined as one in which all process variables remain constant at a given point in the flow path, but vary with distance along the path. This definition has significance for physical and chemical changes and transfer of heat and materials. In an ideal continuous flow process there is no mixing along the axis of the path of flow and there is perfect mixing normal to this axis.

Continuous flow processes are not inherently the best for all situations. Batch processing may be more suitable in many cases.

The great success in the petroleum industry of continuous flow methods has undoubtedly had great influence on developments in the process industries.

The consideration involved in determining whether a particular process or material should be a subject for a continuous or a batch method have been well summarized in Perry's "Chemical Engineering Handbook" (1950), page 1230. These considerations or measures of applicability of batch and continuous flow methods are given in shortened from in Table I.

It is immediately obvious from Table I that pulping in general should be seriously considered for continuous operation inasmuch as all but one of the measures or requirements in Table I (B.) are clearly satisfied. The only exception is the matter of countercurrent operation which, as far as is known, has not been worked out for pulping.

The applicability of continuous pulping, to the cold soda semichemical process and to the rapid pulping of agricultural fibers in particular, will be discussed in the following paragraphs.

CONTINUOUS COLD SODA SEMICHEMICAL PULPING

Types of Processes

The cold soda semichemical process for wood chips, as developed in the United States at the Forest Products Laboratory, Madison, Wis., 6 or 7 years ago, was originally conceived as a simple batch soaking process at atmospheric pressure and included a treating time of 2 to 3 hr. in a caustic soda solution. The treating stage was followed by a conventional continuous fiberizing stage as in all semichemical pulping operations. The batch approach to treating has been carried into industry with apparent success. However, the latest applications of the treating stage are all of the continuous-flow type and, as an indication of their developmental stage, these applications have taken a number of forms as

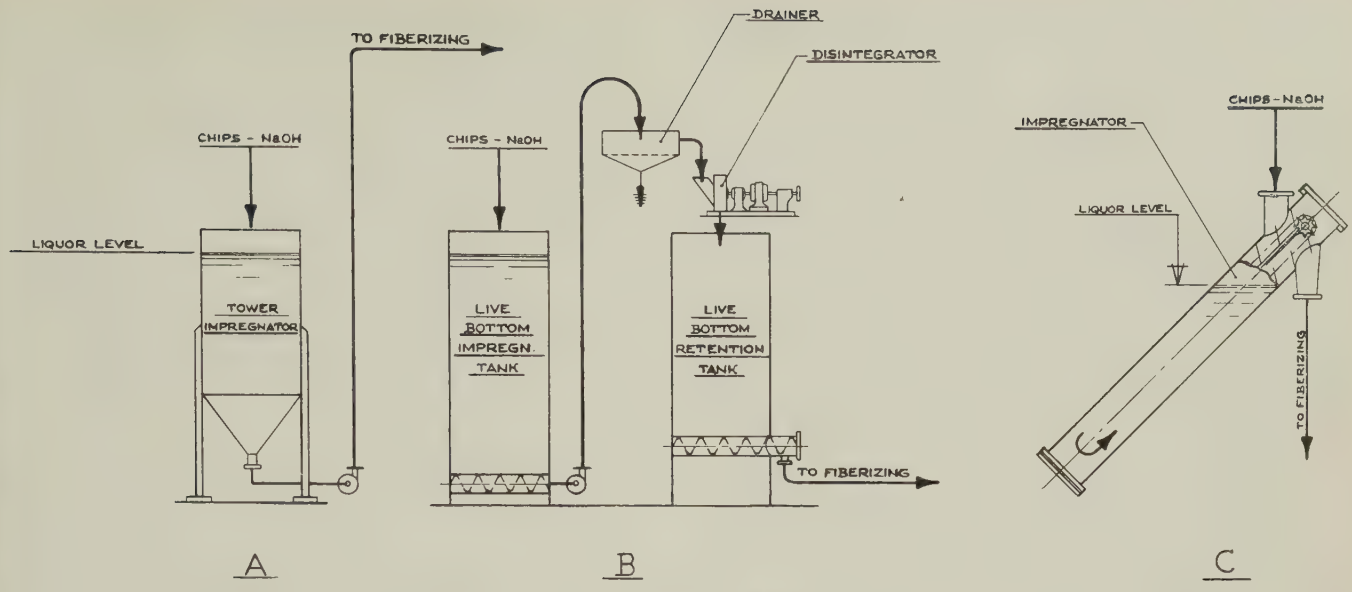

Fig. 1

shown in Figs. 1 and 2. Nearly all of the applications shown in Figs. 1 and 2 are already in commercial installation or planned to be in the near future. Other continuous cold soda treating methods are known to be under development, but details have not yet been released.

From the descriptions available, the new continuous cold soda semichemical applications can be quite logically divided into those involving natural penetrative forces (Fig. 1) and compressive penetrative forces (Fig. 2). With one exception all of the new processes are conducted with the chips immersed in the strong treating liquor for the greater part of the treating period, and there is a recirculation of this liquor. The individual procedures are discussed below.

Processes Employing Natural Penetration

Probably the simplest continuous process is one involving a vessel, which may be of the vertical digester type, as shown in Fig. 1 (a), or otherwise, into which chips and treating caustic soda liquor are introduced and discharged continuously at balanced rates to give a retention time of approximately 2 hr. The chips may be of reduced size in order to improve penetration. A liquid level is maintained in the vessel by the discharge pump working against a head. The liquor is suitably separated from the treated chips by drainage and returned to the treating vessel. The treated chips are then fiberized conventionally.

An advanced version of the simple method above uses the live-bottom bin of semichemical pulping development to obtain the continuous flow of materials with a controlled retention time. This version is shown in Fig. 1 (b). Normal pulping chips, make up caustic soda, and recovered alkali are introduced continuously into a live-bottom bin acting as a primary treating vessel. The treated chips and liquor are then pumped through a single-disk attrition mill for a coarse breakdown in chip size. The smaller, partially treated chips next drop into a second live-bottom bin for completion of the penetration and reactions. The liquor and chips are next discharged into a drainer conveyor and the recovered liquor is returned to the treating bin. The drained chips are finally fiberized and additional liquor may be recovered for re-cycling by means of a screw press. The retention time in the first bin may be 120 min. and in the second 30 min.

A third system employing natural penetration uses an inclined tube arrangement developed for continuous semichemical and full chemical pulping and is shown in Fig. 1 (c). Inasmuch as pressure is not involved, special charging and discharging valves are not required. The chips and liquor (a sulphate liquor in a particular installation) are introduced into the inclined treating tube which comprises two chambers formed by a divider and containing a button conveyor which creates moving pockets for the continuous flow of materials through the treating zone. The retention time is 1 hr. The

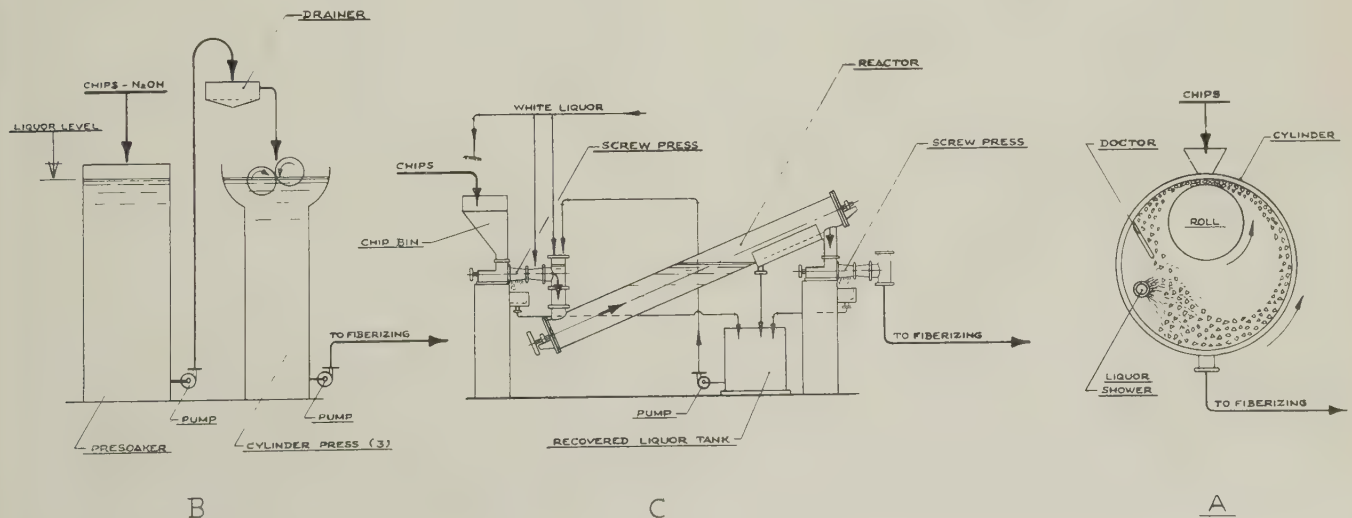

Fig. 2

chips discharge to the fiberizing system which provides additional retention time and includes a screw press for recovering liquor from the fiberized pulp.

Processes Employing Compressive Penetration

Since the natural penetration of caustic soda into wood chips at room conditions depends mainly on the relatively slow-acting force of diffusion, which may take over 2 to 3 hr., continuous processes have been developed to shorten this time as well as to improve the uniformity and completness of penetration. Another factor of considerable significance afforded by reducing the over-all treating time is the control of the reaction time, although this point has not been thoroughly explored up to this time.

The earliest expression of the compressive penetration method was developed at the Forest Products Laboratory in its roller-mill shown in Fig. 2 (a). This method has been described in several publications. In this process the wood chips enter the slightly elevated end of an open treating tube equipped with a single or two opposite, internal peripheral compression rolls. The chips, sprayed with caustic soda liquor, proceed through the tube under alternate compressions and decompressions. The retention time in the treater has been reported to be about 30 sec. The treated chips, which are claimed to be well penetrated and partially defibered, next proceed to the fiberizing system.

The above method is the only one of the continuous processes described in this report which is not conducted with the chips under liquor immersion during a substantial portion of the treatment.

Another compressive penetration procedure is one involving a series of three, two-roll presses taking the form shown in Fig. 2 (b). This method is in practice in an Italian mill and has been described in recently published articles. In this process chips are first partially impregnated in a continuously-operating vessel and then, after drainage of free liquor, are passed through the nip of a two-roll press to emerge under submersion of treating caustic soda liquor. The expansion under liquor of the compressed chips greatly aids penetration. The process is repeated two times by means of two additional two-roll presses in series. The treated and defibered chips are subsequently defibered conventionally. This system is claimed to give uniform penetration with controlled compression and reaction time.

A recently announced continuous cold soda pulping system employing the compressive penetration principle is based on using two screw presses with an intermediate retention or reactor tube as shown in Fig. 2 (c). The screw presses are similar in design to the screw feeder used in continuous semichemical digesters. In this system the chips are first sprayed with caustic soda and they enter a hopper feeding the first screw press. In the first screw press the chips are compressed, relieved of air and excess moisture, and undergo preliminary impregnation. The compressed chips are released at the outlet of the screw press under submergence of the treating liquor and absorb liquor on expansion. The chips, still under liquor submergence, enter the bottom of an inclined reactor tube with a time control screw conveyor. The retention time may be 5 to 20 min. The reacted chips pass over a drainer section of the reactor at its upper end and discharge into the second press. Excess liquor is expressed in the discharge press and the chips receive a preliminary defibering action before entering the fiberizing section of the pulp mill. The drained and expressed liquor is recovered for recirculation as indicated by the requirements of the liquor system. In this particular system the fiberizing is integrated with the treating and is performed by means of a unique, high-consistency disk attrition mill having disks rotating in the same direction at a relatively slow speed. One disk is mounted in a floating housing which has a vertical adjustment to offset the axis of this disk to produce an adjustable relative surface speed of 100 to 250 f.p.m. An excellent defibering action is obtained there-by with unusually low power consumption.

Evaluation of Continuous Cold Soda Pulping Methods

An evaluation of the cold soda processes described above by the measures of applicability of a continuous process given in Table IB results in the conclusion that it is entirely feasible and greatly advantageous to apply continuous flow methods to the chemical treating stage of cold soda semichemical pulping. Brief comments on pertinent points are as follows:

1. *Incomplete Reactions.* The principal reactions involve the hemicelluloses and the lignin-carbohydrate complex of the fiber bond. A minimum of reaction with hemicellulose is desired and only a partial dissolution of the fiber bond is required.

2. *Large Volumes and/or Short Times.* Pulping normally involves large volumes. Because of the shorter time for the compressive penetration systems compared with natural penetration systems, it would appear that the compressive types are especially suitable for continuous flow methods.

3. *Low Material Values.* The high yields, 85 to 90%, and the use of hardwoods give to cold soda pulps the lowest fiber cost of all processes using wood.

4. *Countercurrent Operation.* Countercurrent operation has not had application in the pulping industry.

5. *Excess of a Reactant.* All but one of the methods under discussion, as noted above, are conducted with a high liquid-to-solid ratio. In addition, the treating liquors are used in relatively high concentration.

6. *Precipitation or Extraction.* The hemicellulose removal is essentially an alkaline extraction.

7. *24-Hour Operation.* High capital investment demands that all pulping processes operate 24 hr.

8. *Uncomplicated Testing.* Fairly simple, infrequent testing generally suffices for control in cold soda pulping.

9. *Lengthy Batch Charging and Discharging.* Charging and discharging in batch cold soda pulping may take longer than the actual treating time.

10. *Complex Schedules.* Temperature or pressure schedules are not involved in cold soda pulping.

RAPID CONTINUOUS PULPING OF AGRICULTURAL FIBERS

Developments in Pulping of Agricultural Fibers

Commonly used agricultural fibers are sugar cane bagasse and rice and wheat straw. Corn and cotton stalks have found some usage, and recent developments indicate their serious application in the near future. Although not generally included in this class, cotton linters can quite logically also be considered as an agricultural fiber.

The familiar method for pulping the agricultural fibers has been batch pulping in globe rotary digesters using alkaline pulping reagents. Because of the bulky nature of these materials, the charge to the digester is low, and high liquor-to-solid ratios and very long temperature pressure schedules are required for uniform pulping. Total times of 6 to 12 hr. may be involved.

In the last two years, there have been two extremely important developments in the pulping of agricultural fibers which have changed entirely the concepts of the best way to process these materials. These developments are:

1. The proof by the thorough and extensive investigations by the Hawaiian Sugar Planters' Association, as reported completely at 1957 TAPPI Annual Meeting, that the pulping of sugar cane bagasse should be performed as rapidly as possible, in the time range of 1 to 10 min., to obtain optimum lignin removal and pulp quality.

2. The successful commercial application of continuous pulping systems using the horizontal tube-type continuous

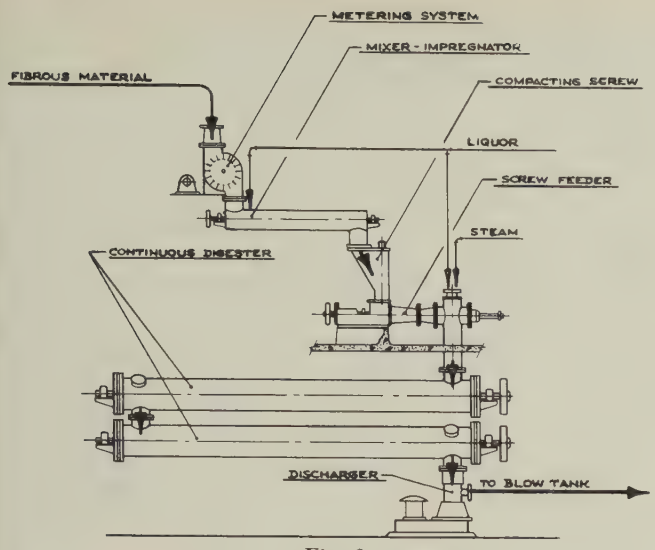

Fig. 3

digesters with the screw feeder and the orifice discharger to implement the rapid pulping principles above. The digestion is preceded by means for metering and for preimpregnating or preconditioning the material. A typical system is shown in Fig. 3.

Certain Results from Pulping Agricultural Fibers

There are presented in Table II results of pulping four agricultural fibers by the older, slow batch methods and the new, rapid continuous method. The comparisons are made for the same degree or range of degrees of pulping. Because of the diverse end-product uses for the various pulps, comparisons of pulp properties are not given with the simplified pulping results in Table II. However, it can be mentioned that in all cases the qualities of the continuous-made pulps were superior to those made by the batch method.

The observations to be made from the comparative data in Table II are as follows:

1. The chemical consumptions are 10 to 15% less in rapid, continuous digestion than in slow batch pulping.
2. The pulping times are spectacularly shorter for the continuous versus the batch method because the time consuming elements of charging, heating uniformly to digestion temperature, and discharging large volumes of liquids and bulky materials have been eliminated.
3. The ratio of liquid-to-solids is greatly reduced. This means a marked reduction in steam consumption and an increase in the solids content of the spent liquor.
4. Although the pressures (and temperatures) in continuous pulping tend to be higher than in conventional batch pulping, this is not a prerequisite with agricultural fibers because of their general ready response to delignification.

The proved advantages of continuous over batch pulping of steady steam demand, low labor, minimum building space, and others are particularly important in pulping agricultural fibers.

Table II. Pulping of Agricultural Fibers

Soda Process

Material	*Type*	*Na_2O, %*	*Conditions for same —degree of pulping— min.*	*p.s.i.*	*Ratio of liquids to solids*
Bagasse	Batch	6–10	60–120	75–100	7:1
	Continuous	5–9	2–10	100–150	2:1
Rice straw	Batch	11.0	120	100	7:1
	Continuous	9.8	6	100	2:1
Wheat straw	Batch	6.0	60	40	7:1
	Continuous	4.7	5	75	3–4:1
Cotton linters	Batch	7.8	120–360	30–105	6–10:1
	Continuous	5.6	18	100	3.5:1

Evaluation of Rapid Continuous Pulping of Agricultural Fibers

An indication of the expedience of pulping agricultural fibers by the rapid continuous method can be gained by applying again the measures in Table IB and making brief pertinent points as follows:

1. *Incomplete Reactions.* Delignification by primary pulping reagents is not economically carried to completion. The final purification is achieved in bleaching. This principle is the same for batch and continuous pulping.
2. *Large Volumes and/or Short Times.* Agricultural fibers can be pulped in extraordinarily short times.
3. *Low Material Value.* Agricultural fibers are basically low cost fibrous materials (except cotton linters), although collection and fuel replacement costs and low yields need to be considered.
4. *Countercurrent Operation.* This point is not known.
5. *Excess of a Reactant.* Pulping of agricultural fibers is conducted with liquid-to-solid ratios of 2:1 to 4:1.
6. *Precipitation or Extraction.* Pulping can be considered as a type of extraction operation.
7. *24-Hour Operation.* Again, equipment investment demands a 24-hr. operation.
8. *Uncomplicated Testing.* Testing of pulps from agricultural fibers represents no particular problem.
9. *Lengthy Batch Charging and Discharging.* Charging of agricultural fibers to batch digester is particularly lengthy in time, whereas the screw feeder, preceded by a positive feed screw, is a very fast material charger. Dumping of batch digesters is also very consuming of time, whereas an orifice discharge takes only seconds.
10. *Complete Schedules.* Preimpregnated or preconditioned agricultural fibers can be subjected immediately to full pulping conditions with no schedule of heating to temperature involved.

CONCLUSIONS

The new segments of the pulping industry, cold soda semichemical and rapid agricultural fiber pulping, have successfully established themselves commercially in the medium of continuous flow pulping methods. These applications answer particularly satisfactorily certain general chemical engineering principles which prescribe continuous flow processes as more suitable than batch processes.

Presented at the meeting of the Virginia-Carolina Section of TAPPI held in Richmond, Va., Dec. 5, 1958.

Tenth

Coating Conference

of the

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Pulp and Paper Industry

Hotel Statler, Boston, Mass.

May 25–27, 1959

LETTERS TO THE EDITOR

X-ray Investigation into the Orientation of Cellulose Fibers in Paper with Respect to the Plane of the Sheet

To the Editor, *Tappi:*

The orientation of the crystalline material in any object consisting of cellulose can in principle be derived from x-ray diagrams. In particular, much work has been done on fiber diagrams. Applications to paper, however, appear to be scarce.

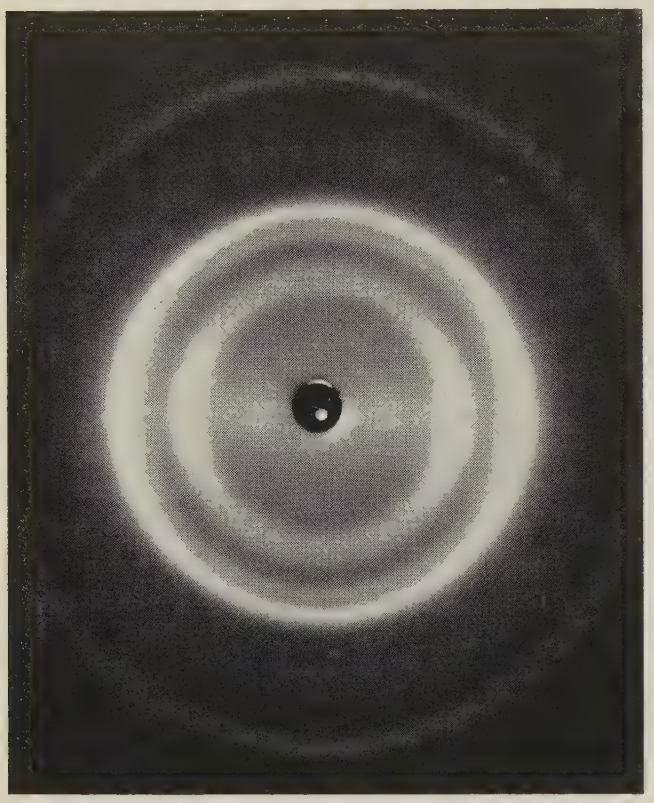

Fig. 1a. X-ray diagram of Rayonier Rayphoto-J cellulose pulp sheet when the incident beam is parallel to the sheet

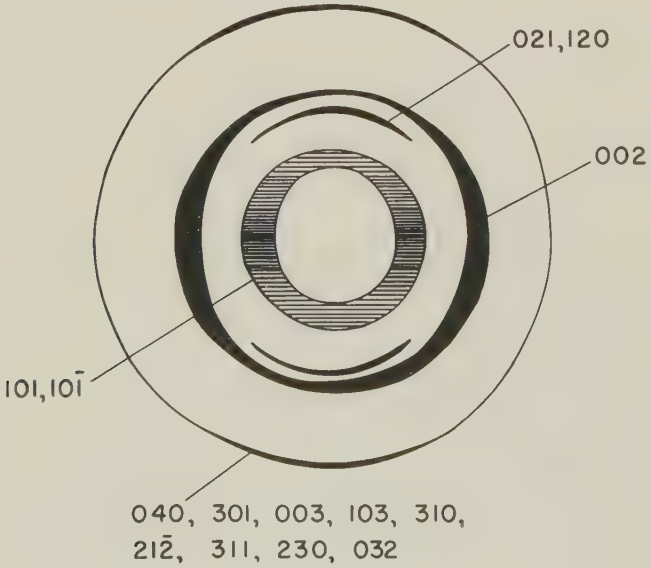

Fig. 1b Indexing according to Andress 2

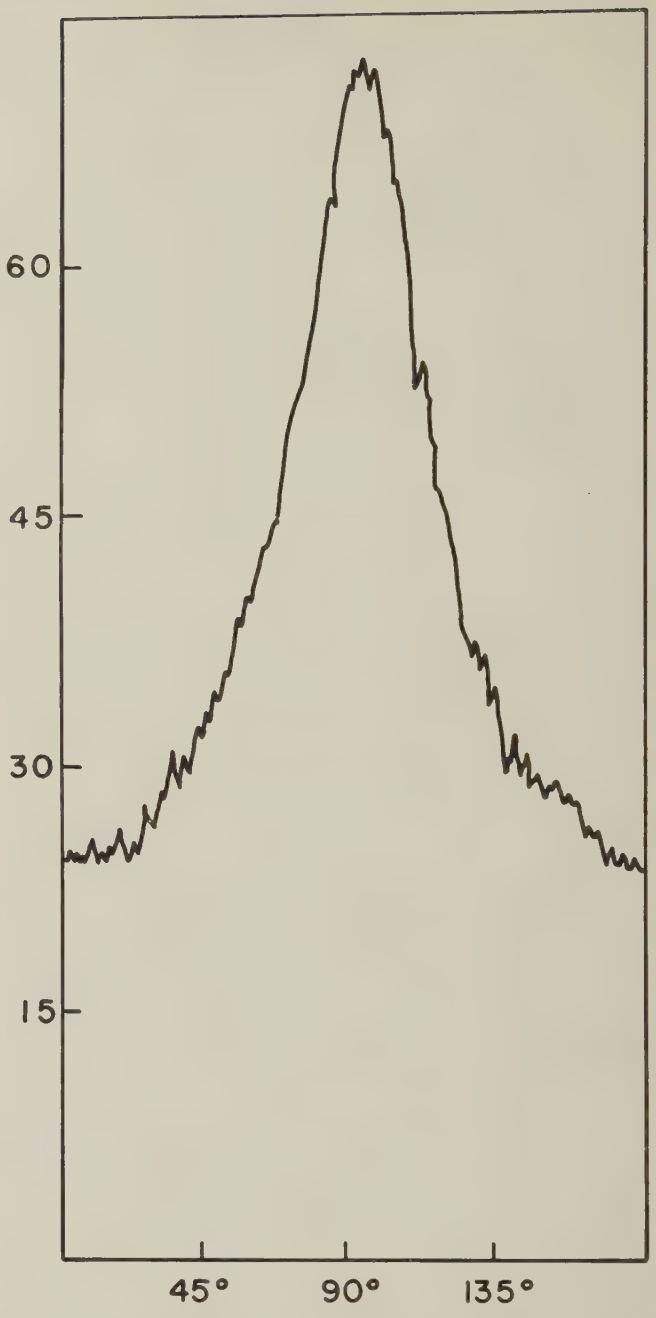

Fig. 2. Density in arbitrary units along (002) circle, measured by counter; ordinary flat paper

Recently, Ruck and Krässig (*1*) published data on the orientation with respect to the machine direction of paper, the incident x-ray beam being perpendicular to the paper sheet, but work on the orientation with respect to the so-called z-direction (perpendicular to the sheet) could not be found in the literature. It is to be expected that this characteristic is related to other physical properties, in particular with the peel resistance, which is of importance in papers for tapes and abrasives. It is easy to show that this orientation can be derived from x-ray diagrams obtained when the incident beam makes an angle with the normal on the paper sheet. Figure 1a shows the diagram obtained when this angle is 90°, i.e., when the incident beam is parallel to the paper sheet. In this example, a Rayonier Rayphoto-J cellulose pulp sheet was used.

The orientation of the crystalline cellulose with respect to the plane of the sheet can be derived from the density distribution along the paratropic reflections (002) or (101, 10$\bar{1}$).

The (021, 120) reflections could be used instead, but they are rather weak and occur close to the (002) circle. The use of the diatropic reflection (040) would be unreliable, because its diffraction angle is very close to that of several other crystallographic planes (compare Fig. 1b). If the orientation derived from (002) differs appreciably from that derived from (101, 10$\bar{1}$), this indicates that certain paratropic planes are oriented preferably in the plane of the paper sheet.

Figure 2 is an example of the density distribution along the (002) reflection for an ordinary flat paper. This was measured with a Geiger counter goniometer; here again, the incident beam was parallel to the paper sheet. The possible effect of a machine direction was eliminated by using a stack of several sheets in which the machine and cross-directions were alternating. In experiments with other papers, such as extensible papers (microcrepe and macrocrepe), it was found that different papers show significant differences in orientation with respect to the z-axis. An investigation into the correlation with other properties is underway.

E. A. Aaltio, W. Prins, and J. J. Hermans
Cellulose Research Institute
State University College of Forestry
Syracuse 10, N. Y.

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1. H. Ruck and H. Krässig, *Pulp & Paper Magazine of Canada* 59, nr. 6, 183 (1958).
2. K. Andress, *Z. physik. Chem. 136*, 279, 282 (1928).

RECENT BOOKS

Pulp and Paper Manual of Canada, 26th Ed., 1958. National Business Publications, Ltd., Gardenvale, Quebec, Canada. Buckram, 8 × 10, 470 pages. $8.00.

Previous editions of the Manual have been reviewed in *Tappi*. The format remains the same from year to year but the text and the advertisements reflect the progress and advances being made in the pulp and paper industry. Excellent flow diagrams are shown of a large number of mills. Among the editorial items are several economic reviews of paper and especially newsprint manufacture. The book is essentially a catalog of equipment and supply companies.

Modern Chemical Processes. Vol. 5. By Editors of *I. & E. C.* Reinhold Publishing Co., New York, 1958. Cloth 1/2, 8 × 11 1/4, 154 pages. $5.00.

A series of articles describing chemical manufacturing plants. Volume 5 covers such subjects as elemental phosphorus, natural gas hydrocarbons for petrochemicals, gold processing, uranium from gold waste, boron chemicals, dualayer gasoline process to remove mercaptans.

Epoxy Resins. By Irving Skeist. Reinhold Publishing Corp., New York, 1958. Cloth, 5 × 7 1/2, 292 pages. $5.50.

Gum Plastics (Rubber—Modified Plastics). By M. S. Thompson, Naugatuch Chemical Div. Reinhold Publishing Corp., New York, 1958. Cloth, 5 × 7 1/2, 193 pages. $4.50.

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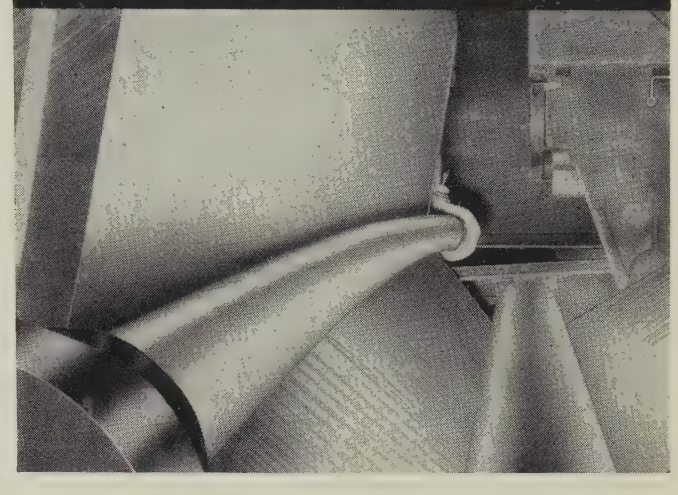

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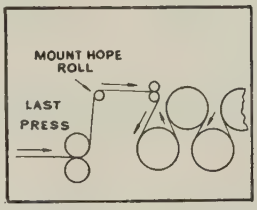

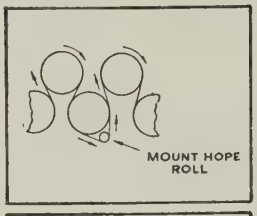

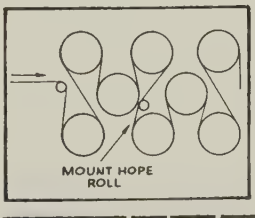

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Vinyl Resins. By W. Mayo Smith, Escambia Chemical Corp. Reinhold Publishing Corp., New York, 1958. Cloth, 5 × 7½, 282 pages. $5.75.

Three recent additions to the Reinhold Plastics Application Series written by experts in their respective fields. All books in the series cover the scope, types and properties, chemistry, manufacture and fabrication, applications and need developments. They are excellent reviews for the individual who wishes to obtain a quick description of these new products. They are written in nontechnical language by people who know these subjects.

Oral Communication of Technical Information. By Robert S. Casey, W. A. Sheaffer Pen Co. Reinhold Publishing Corp., New York, 1958. Cloth, 5 × 7½, 199 pages. $4.50.

A pocketbook of effective help for science speakers. It is largely "how to-do-it" book covering composition for oral delivery, formally prepared talks, presiding at meetings, talking science to laymen, technical legal testimony, and social conversation.

Technical Editing. Edited by B. H. Weil, Esso Research and Engineering Co., New York, 1958. Cloth, 5 × 7½, 278 pages. $5.75.

A pocketbook useful to anyone who is involved in industrial communications. Among the subjects covered are psychological, educational, and professional aspects of technical editing, internal editing of technical papers and articles, editing organization-sponsored magazines and newsletters, editing from the patent standpoint, editing and publishing technical abstracts for internal use, news releases, editing equipment manuals, editing slides and other aids and editing translations.

Creative Thinking. By Charles S. Whiting. Reinhold Publishing Corp., New York, 1958. Cloth, 5 × 7½, 168 pages. $3.95.

A pocketbook of the Reinhold Management Science Series dealing with the concept that people can develop their ability to produce new ideas. An attempt is made to point out the sensationalism and charlatanism that should be recognized and avoided. Brief chapters deal with such subjects as changing existing ideas, brainstorming, The Gordon Technique, presenting ideas, company programs, the future of creative thinking.

Punched Cards. 2nd Ed., Edited by Robert S. Casey, James W. Pery, Allen Kent, and Madeline Berry. Reinhold Publishing Co., New York, 1958. Cloth, 6 × 9, 695 pages. $15.

The previous edition was reviewed in *Tappi*. The present edition is a revision and enlargement of the text. The field has grown rapidly. The bibliography of the first edition contained 276 entries in contrast to 400 entries in the new edition. Greater attention is given to practical applications.

Automatic Process Control. By Donald P. Eckman of Case Institute of Technology. John Wiley & Sons, Inc., New York, 1958. Cloth, 6 × 9, 368 pages. $9.00.

Dr. Eckman, who is a professor of instrumentation engineering, deals with the important principles of automatic control that should be known to the engineer. System problems are given much attention. An outline of the chapter titles will indicate the scope: Process Characteristics, Controller Characteristics, Closed Loop in Automatic Control, Measuring (Feedback) Elements, Controlling Elements, Process Instrumentation, Sinusoidal Analysis and Stability Analysis. A knowledge of calculus and differential equation by readers is assumed by the author.

Chemical Process Economics. By John Happel, New York University. John Wiley & Sons, Inc., New York, 1958. Cloth, 6 × 9, 291 pages. $8.50.

Dr. Harpel is a professor of chemical engineering and in this volume emphasizes the quantitative viewpoint and combines this with the qualitative considerations involved in management and the general social implications of engineering economy. He deals with economic balance, special mathematical techniques, cost estimation, risk, return rate and investment recovery, process plant components. The appendix is useful since it treats with a member of rule of thumb consideration, cost data, and a summary of formulas and tables.

Process Dynamics. By Donald P. Campbell, formerly professor at M. I. T. John Wiley & Sons, Inc., New York, 1958. 6 × 9, 316 pages. $10.50.

The purpose of this book is to explain process physics. It is based on the author's research experience in feedback control theory and process control. He points out that the fields of instrumentation and process control are little more than empirical arts and are not founded upon a sound scientific basis. The author deals with materials in motion, fluids in motion, forming, propulsion and guidance, thermal process dynamics, mass transfer dynamics, and chemical process dynamics.

Information and Communication Practice in Industry Edited by T. E. R. Singer, Program Chairman, Div. of Chemical Literature, American Chemical Society. Reinhold Publishing Co., New York, 1958, Cloth, 6 × 9, 304 pages. $8.75.

Consideration is given by the many chapter authors to the operation of an information department in an industrial concern in contrast to the more common library and library information service. A very large information department may include among its activities the organizations and operations of research files of reports, of patents, and special information material. It may take over the preparation of reports. Among the subjects covered are internal communications, language and terminology, operations research, technical classification, patent collections, punched cards, technical translation, editing, indexing, and abstracting.

Modern Materials. Edited by Henry H. Hausner. Academic Press, Inc., New York, 1958. Cloth, 6 × 9, 402 pages. $12.50.

Knowledge of materials has increased so rapidly in recent years that it was felt by the author and a number of his associates that a series of volumes dealing with modern materials should be prepared and published. This volume concerns itself with new developments in wood as a material, synthetic rubbers for special service conditions, fiber materials, high voltage insulation papers, special glasses for nuclear engineering applications, germanium and silicon, zirconiums, and modern ceramics.

The Encyclopedia of Chemistry (Supplement). Edited by George L. Clark and Gessner G. Hawley. Reinhold Publishing Co., New York, 1958. Cloth 7 × 10, 330 pages. $10.

The Encyclopedia was reviewed in *Tappi*. The Supplement adds 200 concise articles to the Encyclopedia. The subjects are arranged alphabetically from acidimetry, alum, asphalt, chemical education, chemical process equipment, combustion, drying, engineering materials, legal chemistry, particle size, rosin, statistical techniques etc. to zeolites.

The Bolton Award—1958. Issued by John W. Bolton & Sons, Lawrence, Mass., 1958, 6 × 9, 61 pages.

The prize winning essays offered in the Elements Bolton Award on the subject: "How Can I Help Relations Between My Company and My Community." The first prize was won by John R. Bentley, Asst. Sales Manager, Western Kraft Corp., Albany, Ore.

Book reviewed in this section may be secured from TAPPI, 155 East 44th St., New York 17, N. Y.

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Fractionation of Paraffin Waxes by Laboratory Procedures—Compositional Effects

K. G. ARABIAN

In planning wax research programs wherein composition is to be a variable, fractional crystallization and distillation are almost always used to separate the samples being studied. They are sometimes used alone, sometimes together, and sometimes in conjunction with other separating techniques such as adduct formation or chromatographic separation. In many cases, the research program does not require the preparation of individual pure compounds, and concentrates of each structural type are prepared. In other programs, the important qualification may be that the fractions be narrow in molecular weight spread.

Fractions have been prepared by crystallization and distillation for many years, but until recently, the compositions of the fractions could only be estimated by measurement of their physical properties. When mass spectrometer techniques for analyzing wax compositions (*1–4*) became available, it was considered valuable to learn and record the kind of fractions which are produced by laboratory distillation and/or crystallization.

MATERIALS AND METHODS

Two commercial waxes were used for studying the composition of fractions produced by laboratory crystallization and distillation procedures. They were a 122/124 FRP (fully refined paraffin) wax (P-38-A) and a 138/140 FRP wax (P-177).

The fractionation by crystallization was carried out in the following manner: a weighed sample of wax was dissolved in ten times its weight of methyl isobutylketone (MIBK) and the mixture cooled until approximately 10%w of the wax was precipitated. The precipitated wax was filtered, washed, and freed of solvent. Successive 10%w fractions (basis original wax) were precipitated by further cooling of the filtrate.

For preparation of fractions by distillation, the 122/124 FRP wax was distilled in a semimicro rotary-ribbon column (*5*). The column was operated at a spinning-band speed of 3600 to 4200 r.p.m. Boil-up rate was 3600 ml. per hr. at 1 mm. Hg absolute pressure. The reflux ratio was 50:1 for the major portion of the distillation and was decreased to 20:1 for the last 10 to 15%w of the material distilled overhead. It is estimated that, under the conditions used in this distillation, the rotary-ribbon column was equivalent to 10 to 12 theoretical plates.

K. G. Arabian, Houston Research Laboratory, Shell Oil Co., Houston, Tex.

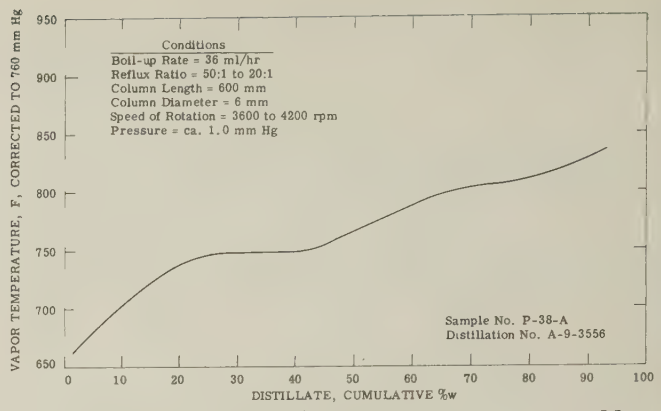

Fig. 1. Distillation of 122/124 FRP wax in a rotary-ribbon column, charge = 75.0 g.

For distillation of the 138/140 FRP wax, a Vigreaux column was used (*6*). For the distillation reported here, a column 6 ft. long and 1 in. in diameter was employed. The boil-up rate was 95 ml. per hr. at 1 mm. Hg absolute pressure. Initial reflux ratio was 4:1 and was lowered to 2:1 for the latter 15 to 20%w of material distilled overhead.

Each of the fractions obtained by crystallization was analyzed by mass spectrometric techniques. In the distillation studies, selected fractions covering the whole range of the distillations were analyzed.

DISCUSSION OF RESULTS

Fractionation of 122/124 FRP Wax by Crystallization

The yields and properties of the ten fractions recovered from the fractional crystallization of the 122/124 FRP wax are listed in Table I, along with a summary of the analysis of each fraction. The crystallized fractions (1 to 9) varied in melting point from 106.5 to 129.5°F. The molecular weight spread of the fractions varied from 8 to 12 carbon atoms per molecule as compared to 13 carbon atoms per molecule for the charge stock. There was some fractionation by structural type as shown by variations in the normal alkane content of the fractions. For example, the normal alkane content of the fractions varied from 92.2v to 99.2%v, compared to 97.2%v for the original wax. Lower-melting fractions containing an appreciable concentration of isoalkanes and saturated single ring compounds were produced by the crystallization procedure.

Fractionation of 122/124 FRP Wax by Distillation

The distillation curve of the 122/124 FRP wax (distilled in rotary-ribbon column) corrected to 760 mm. Hg is shown in Fig. 1. Fractions representing about 1.6%w of the charge were taken and, of the 66 fractions obtained, fractions 11, 16, 28, 39, 51, and 66 were analyzed using mass spectrometric

Table I. Fractional Crystallization of 122/124 FRP Wax (P-38-A); Solvent: 10/1 MIBK

Fraction no.	*Yield, %w*	*Congealing point (D-938), °F.*	*Carbon number range of fraction*	*Molecular weight spread of fraction, number of carbons*	*Mass spectral analysis, %v*		
					n-Alkanes	*Isoalkanes*	*Saturated cyclic compounds*
1	7.2	129.5	C_{21}-C_{32}	12	99.2	0.8	...
2	14.1	127.5	C_{21}-C_{30}	10	99.2	0.8	...
3	11.5	126.5	C_{20}-C_{30}	10	99.2	0.8	...
4	7.2	125.5	C_{21}-C_{31}	11	99.2	0.8	...
5	12.1	124.5	C_{20}-C_{28}	9	98.8	0.6	0.6
6	13.7	122.0	C_{20}-C_{28}	9	98.2	1.2	0.6
7	9.4	120.5	C_{20}-C_{28}	9	97.4	1.2	1.4
8	10.9	117.5	C_{20}-C_{28}	9	95.6	2.9	1.5
9	9.1	106.5	C_{20}-C_{27}	8	92.2	4.0	3.8
10[a]	4.8	82.0	C_{20}-C_{28}	9	68.4	12.2	19.4
Charge to the fractional crystallization (P-38-A)	100	123.0	C_{20}-C_{32}	13	97.2	2.0	0.8

[a] Fraction no. 10 is from the final filtrate.

Table II. Distillation of 122/124 FRP Wax (P-38-A) in a Rotary-Ribbon Column[a]

Fraction no.	Yield, %w	Congealing point (D-938), °F.	Carbon number range of fraction	Molecular weight spread of fraction, number of carbons	Mass spectral analysis, %v		
					n-Alkanes	Isoalkanes	Saturated cyclic compounds
11	1.8	114.0	C_{21}-C_{23}	3	100	Trace	...
16	1.5	117.5	C_{21}-C_{24}	4	100	Trace	...
28	1.6	119.5	C_{22}-C_{25}	4	100	Trace	..
39	1.4	127.0	C_{23}-C_{26}	4	100	Trace	...
51	1.5	132.0	C_{24}-C_{27}	4	97.2	2.1	0.7
66[b]	7.0	149.5	C_{27}-C_{32}	6	88.3	5.1	6.6
Charge to the distillation (P-38-A)	100	123.0	C_{20}-C_{32}	13	97.2	2.0	0.8

[a] Distillation conditions are shown in Fig. 1. Each fraction represents about 1.6%w of the charge to distillation.
[b] Fraction no. 66 is the residue and contains 7% of the charge to distillation.

techniques. The properties, yields, and summary mass spectrometric analyses for these fractions are given in Table II. The melting points of the overhead fractions varied from 114 to 132.0°F. There was a definite narrowing of the molecular weight spread from 13 carbon atoms per molecule for the charge to 3 and 4 carbons for the overhead fractions. Further evidence of this narrowing of the molecular weight spread is shown by the 6-carbon width of the residue from the distillation. Some separation by types of hydrocarbon

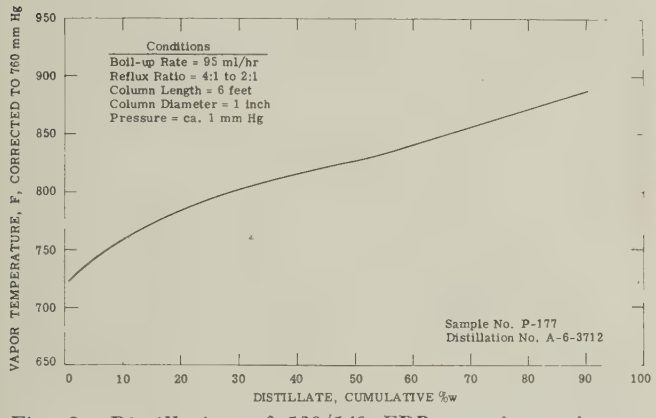

Fig. 2. Distillation of 138/140 FRP wax in a vigreaux column, charge = 2530 g.

was observed. Examination of the data show the normal alkane content of the fractions ranged from 97.2v to 100%v, compared to 97.2%v for the original wax. The residue contained 88.3%v normal alkanes. The isoalkanes and saturated single ring compounds were concentrated in the highest-boiling 22% of the charge.

Fractionation of 138/140 FRP Wax by Crystallization

The properties, yields, and summary mass spectrometric analyses of the ten fractions obtained from the 138/140 FRP wax by fractional crystallization are shown in Table III. Crystalline fractions ranging in melting point from 113 to 149°F. were produced. As in the case of the fractional crystallization of the 122/124 FRP wax, some narrowing of the molecular weight spread was accomplished. The width of the fractions was 16 to 18 carbons, compared to 19 carbons for the charge stock. Considerable separation of types was observed. The normal alkane contents of fractions 1 to 9 varied from 40.1 to 92.0%v, compared to 78.7%v for the charge stock. The isoalkane contents of the fractions varied from 4.0 to 20.0%v, compared to 8.9%v in the charge stock. The concentrations of single ring saturated compounds ranged from 4.0 to 31.4%v in the fractions, compared to 10.3%v in the original wax.

Fractionation of 138/140 FRP Wax by Distillation

The distillation curve for the 138/140 FRP wax (distilled in a Vigreaux column) corrected to 760 mm. Hg is shown in Fig. 2. Fifty-seven cuts, each approximately 1.8%w of the charge, were prepared. Fractions 1, 6, 11, 16, 21, 26, 31, 36, 41, 46, 51, 56, and the residue were analyzed using mass spectrometric methods. The properties, yields, and summary analyses of the fractions are given in Table IV. The overhead fractions ranged from 116 to 153.0°F. in melting point. The analyses show there was a pronounced narrowing of the molecular weight spread from 19 carbon atoms per molecule in the charge to 5 and 6 carbons in the fractions from the distillation. The normal alkane content of the fractions show (like those of the fractions from distillation of the 122/124 FRP wax) some separation by hydrocarbon type, varying from 67 to 100%v, compared to 78.7%v in the original wax. The isoalkane content of the fractions ranged from 3.4 to 14.4%v, compared to 8.9% in the charge. The concentration of saturated single ring compounds in the fractions varied from 4 to 15.0%v as compared to 10.3%v for the charge wax.

Table III. Fractional Crystallization of 138/140 FRP Wax (P-177); Solvent: 10/1 MIBK

Fraction no.	Yield, %w	Congealing point (D-938), °F.	Carbon number range of fraction	Molecular weight spread of fraction, number of carbons	Mass spectral analysis, %v				
					n-Alkanes	Isoalkanes	Monocyclo-alkanes	Dicyclo-alkanes	Other compounds
1	5.1	149	C_{23}-C_{39}	17	92.0	4.0	4.0	...	...
2	11.2	148	C_{23}-C_{39}	17	89.8	5.1	5.1	...	...
3	12.9	147	C_{23}-C_{38}	16	88.1	6.1	5.8	...	...
4	17.1	144	C_{23}-C_{38}	16	83.4	7.3	9.3	...	..
5	14.9	139	C_{23}-C_{38}	16	79.8	8.0	10.1	2.1	...
6	14.2	136	C_{22}-C_{38}	17	72.4	11.5	13.0	3.1	..
7	10.9	126	C_{21}-C_{38}	18	62.1	13.5	20.5	3.9	...
8	6.9	121	C_{21}-C_{38}	18	51.9	17.5	23.7	6.7	0.2
9	4.8	113	C_{21}-C_{37}	17	40.1	20.0	31.4	8.2	0.3
10[a]	2.0	107	C_{21}-C_{38}	18	38.6	19.6	30.8	10.6	0.4
Charge to the fractional crystallization (P-177)	100	138	C_{21}-C_{39}	19	78.7	8.9	10.3	2.0	0.1

[a] Fraction no. 10 is from the final filtrate.

Table IV. Distillation of 138/140 FRP Wax (P-177) in a Vigreaux Column[a]

Fraction no.	Yield, %w	Congealing point (D-938), °F.	Carbon number range of fraction	Molecular weight spread of fraction, number of carbons	Mass spectral analysis, %v				
					n-Alkanes	Isoalkanes	Monocyclo-alkanes	Dicyclo-alkanes	Other compounds
1	1.9	116	C_{21}-C_{26}	6	100.0	...	...	...	...
6	1.6	128	C_{23}-C_{28}	6	96.6	3.4	...	...	...
11	1.7	132.5	C_{24}-C_{28}	5	94.9	5.1	...	...	...
16	1.8	135.5	C_{25}-C_{29}	5	92.9	7.1	...	...	...
21	1.6	138.0	C_{26}-C_{30}	5	87.5	8.5	4.0	...	...
26	1.8	140.5	C_{27}-C_{31}	5	82.3	11.6	6.1	...	...
31	2.1	142.5	C_{28}-C_{32}	5	80.2	11.2	8.6	...	...
36	1.6	145.0	C_{28}-C_{32}	5	75.8	13.0	11.2	...	...
41	1.7	146.5	C_{29}-C_{33}	5	74.1	12.9	13.0	...	...
46	2.4	148.0	C_{30}-C_{34}	5	70.5	13.3	14.8	1.4	...
51	1.6	151.5	C_{31}-C_{35}	5	67.4	14.4	15.0	3.2	...
56	1.4	153.0	C_{33}-C_{38}	6	67.0	12.9	11.4	8.4	0.3
Residue	4.5	159.5	C_{35}-C_{40}	6	67.0	11.6	11.0	9.4	1.0
Charge to the Distillation (P-177)	100	138	C_{21}-C_{39}	19	78.7	8.9	10.3	2.0	0.1

[a] Distillation conditions are shown in Fig. 2. Each fraction represents about 1.8%w of the charge to distillation.

CONCLUSIONS

It is recognized that the distillation procedure used in these studies is a multistage separation, whereas the fractional crystallization is a single stage operation. Theoretical comparisons of the separation efficiencies would therefore be misleading. Nevertheless, a discussion of what each procedure accomplishes in terms of composition of the resulting fractions is of interest to anyone planning to use these techniques.

Narrowing the Molecular Weight Spread

For producing fractions which are narrow in molecular weight spread, the distillation procedure appears to be preferable. In the case of both waxes, the fractions produced by distillation were decidedly narrower in molecular weight spread than fractions produced by crystallization (Tables I, II, III, and IV). Fractions varying between 3 and 6 carbons in molecular weight spread were produced by the distillation procedure; the crystallization procedure produced fractions which were 9 to 17 carbons wide.

Separation of Structural Types

For preparing concentrates of a single structural type, distillation of fully-refined paraffin waxes produced some fractions which were 100% *n*-alkanes. This may be seen in Tables II and IV, and can be explained on the basis of sample history. Distillation of petroleum fractions in the wax molecular weight range normally does not cause a separation of structural types. When distilling fully-refined paraffin waxes, high concentrations of *n*-alkanes occur in the first distillate cuts only by virtue of the previous processing history of the sample. A fully-refined paraffin wax has been subjected to two separations by crystallization (dewaxing and deoiling) and during these operations the lowest molecular weight nonnormal alkanes are removed from the wax. Consequently, there are no nonnormal alkanes in the lighter fractions of a distilled wax. This performance was recognized and patented by Schaerer (*7*). For producing fractions which contain isoalkanes in high-concentration, neither crystallization nor distillation showed any particular advantage, although each accomplished some separation. For preparing fractions which contain high concentrations of cycloalkanes, crystallization is more efficient than distillation. This is indicated by the data in Tables III and IV. A difference in melting range between fractions produced by distillation and by crystallization should be pointed out here. The cycloalkanes are concentrated in fractions which are lower melting than the charge when the fractions are prepared by crystallization, whereas they are concentrated in fractions which are higher in melting point than the charge when prepared by distillation.

In conclusion, distillation of a wax results in fractions which are narrow in molecular weight spread compared to the charge, while crystallization on the other hand does not appreciably affect the molecular weight spread of the fractions.

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Development of a new Test to Measure the Response of Paper to Printing Press Variables

Robert J. LaFond

This report is concerned with (1) letterpress printing of paper on a laboratory proof press; (2) development of an objective method for evaluating one aspect of solid coverage print quality; (3) application of the technique to determine the response of paper to letterpress printing conditions.

BACKGROUND

How big is the printing industry? How does it compare with the pulp and paper industry? A few figures (from the 1954 census of manufacturers) will serve as a comparison (*1*):

	Industry	All Employees	Payroll
A.	Pulp and paper products	530,000	$ 2,217,000,000
B.	Printing and publishing	804,000	3,625,000,000
	Total industry	16,126,000	65,977,000,000

Manufacturers of printing buy annually about 2 billion dollars worth of machinery, equipment, and supplies, including ink

Robert J. LaFond, Central Technical Dept., St. Regis Paper Company, Deferiet, N. Y.

and paper. There are about 45,000 printing plants ranging in size from one to two-man shops to big ones like Donnelley's and the New York Times. The yellow classified pages for Manhattan alone list several hundred names under the headings: Printers, Printing, and the like. Of the 30 million tons of paper and board produced annually, possibly 50% or more is printed, and the printing industry is growing rapidly. The general trend is toward more multicolor work, faster running presses, faster drying inks, and the use of web-fed equipment.

What does this mean to the papermaker who is manufacturing grades for the printing industry? One of our aims should be to advance the printer's art technologically and to keep his costs down and his quality up so that his prospective customers will want their work printed. If the printer has more work, he'll buy more paper. Therefore, in reality, the printer's problems are our problems. The printer's problems are numerous and sometimes complex and provoking. In the letterpress industry, one of the biggest problems is make-ready in which, among other things, the pressman tries to compensate for variations in the material he uses even when these variations are within commercial tolerances. A few of the problems that the printer faces are plate thickness variation, plate register trouble in multicolor work, the lack of plate flatness for flat bed presses, variation in plate curvature for rotary presses, variations in ink characteristics, and variations in paper characteristics. These are among the many factors that affect "printability."

Papermakers are interested in the quality of their products and they normally perform tests in an effort to forecast "printability." The tests performed usually can be classified into two categories:

1. Those in which prints are actually made and are examined for quality.
2. Those in which measurements are made on the physical properties which seem to be important. Efforts are made to correlate these measurements with the commercially printed results.

Most papermakers make use of one or both of these approaches. However, interpretation of the printed results or correlation of physical properties with commerical results is very difficult. The most desirable method of determining the "printability" of paper or really the suitability of paper for a job is, of course, to make a trial of the actual commercial job on the commercial machine, and, if the results are satisfactory, future orders are made as similar as possible to the satisfactory paper. This method, however, is not entirely satisfactory. Besides being time consuming and otherwise costly, it often fails to give the basic reasons why the paper is or is not satisfactory from the print quality standpoint. It is, therefore, difficult if not impossible to improve print quality of an unsatisfactory sheet except by qualified guess work.

The word "printability" has been used several times. What does it mean? It is not a simple word to define. Each of us probably has his own definition. At the Second International Conference of the Printing Research Institutes held in 1953 (*2*), a definition for *printability of paper* was proposed and adopted. The people responsible for the definition expressed dissatisfaction with it because of its length and nature, but it is probably the best available. It is:

"The printability of paper is a collective term used to describe the many physical and chemical properties of paper which control the production of prints of the desired quality in sufficient numbers at the desired rate according to the particular printing process used.

"A paper of satisfactory printability is required to accept the correct amount of printing ink in the desired areas; it should not adversely affect the desired rate of drying the printing ink; it should possess the necessary smoothness, porosity to inks and ink media, optical properties (opacity, colour and gloss), rheological properties (compressibility and elasticity), strength and resistance to picking and fluffing of the surface layers and stability to changes in humidity. Its chemical properties should be such that it does not affect the permanence and colour of the printed image or adversely affect the printing plate. If in sheet form, it should be squarely cut and flat. If in reel form, it should be evenly wound. There should be no loose fibers or dust on the surface. The paper should not be abrasive and it should not be unduly susceptible to the generation and retention of static electrical charges.

"It should be noted that the printability of paper cannot be measured by one property alone and the importance of the various properties will depend on the printing process used, on the quality required of the finished print, and its production rate."

For purposes of this paper, let's forget about this all-inclusive word "printability" and deal with the specific phases of it which are of immediate interest to us.

DISCUSSION AND RESULTS

We are concerned with letterpress printing of uncoated paper. Further, we are concerned only with the way the printed image on the paper agrees or disagrees with the printing surface on the plate. The plate in this work is a smooth, continuous surface $2^1/_2$ in. wide and $8^1/_2$ in. long, so we are concerned only with printing of this so-called solid. Furthermore we are interested only in the quantity of brakeup or uninked spots in the area covered by the plate which we will refer to as solid coverage quality in this report. We are going to test for this quality factor by actually printing with a 15–21 Vandercook proof press.

There are many variables on the proof press other than the paper to be printed, which will affect this solid coverage quality. Some of the major variables are impression, printing speed, quantity of ink used, ink characteristics, form roller condition and settings, quality of the plate, ink distribution time, and mechanical conditions of the press. A pressman on a commercial press has to contend with these same variables.

Impression—what is it? For printing purposes, impression is the amount of squeeze used in printing, i.e., 0.005 in. of impression means that the press is made ready with 0.005 in. more squeeze than there is clearance between the plate and the paper. Impression may vary from 0.003 in. for the finest printing on the best coated papers to 0.020 in. or more for carton printing on board.

What conditions should be chosen on a proof press to determine the solid coverage quality of paper or to compare this feature for two different papers? Many of the press factors mentioned are fixed or should be checked and set, such as form roller surface and settings, plate quality, and mechanical conditions of the press. The ink distribution time for the ink added to the press initially should be such that uniform distribution is a certainty. The time allowed for distribution between prints should be sufficient to assure uniform distribution of the ink left or added to the system. The ink to be used preferably should be one that is identical to that used on the commercial job, with the possible exception that no dryer is added. The maximum printing speed may be dictated by design as far as the proof press is concerned, but efforts should be made to control the printing speed within narrow limits at the particular speed chosen. This leaves as major undefined variables, the impression and the ink film thickness.

Ideally, for testing, the impression and, therefore, ink film thickness for a particular color should be that which is used by the commercial printer. However, it is difficult, if not impossible, for the printer to define these two factors in absolute terms. A portion of letterpress make-ready is performed to obtain the levelness of impression desired for each job. When make-ready is completed, the pressman may not have the desired perfect levelness of impression for each image across a wide press, but he will be within the range of levelness dictated by the quality requirements of the job. When satisfactory levelness has been obtained, the impression can be increased or decreased by packing changes. Impression

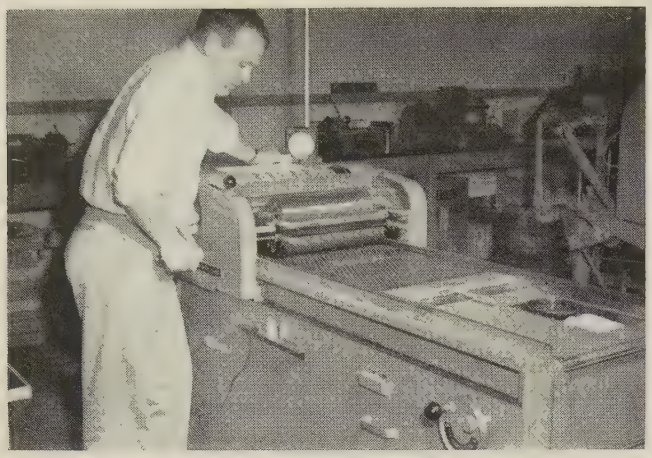

Fig. 1

normally can be described only by the commercial printer in general terms such as light or heavy because the letterpress pressman can only guess within plus or minus several thousands of an inch as to what the squeeze really is. Embossing of the printed area is caused by heavy impression and is usually undesirable. To obtain a commercially satisfactory job, the coverage, color, and showthrough must be satisfactory somewhere within the limits of the range of impression and the range of ink film thickness that can be used.

Since it is difficult for the commercial printer to describe the impression and ink film thickness he uses, it is all the more difficult for the paper tester to decide on the conditions he should use on his press. Ordinarily, for testing purposes, when comparing two papers, the impression and ink film thickness used are such that the print on the paper which is easiest to cover will show slight amounts of breakup in the solid printed areas of the paper. This quantity of ink will then allow good discrimination between the easy- and hard-to-cover papers. But the question which arises is how does the difference in breakup at these chosen testing conditions compare with the amount of ink needed on both papers for complete coverage at the chosen impression, or for complete coverage at other amounts of impression? This is an impossible question to answer objectively without additional experimental work.

Before this work could be done, however, a satisfactory method for objectively evaluating solid coverage print quality had to be found or developed. The three primary requirements of such an evaluation technique are:

1. The values obtained by the instrument must rank the prints in the same order as is obtained by visual ranking, when the visual ranking is done by qualified judges.
2. The instrument must be very sensitive so that small but visual differences may be detected.
3. The instrument results must be reproducible within narrow limits, depending on its sensitivity.

It was believed that optical instruments might meet these requirements and, therefore, that they should be investigated as a means of evaluating prints for solid coverage print quality.

To check these instruments, a series of prints was made under carefully controlled press conditions on the 15–21 Vandercook proof press. Figure 1 is an over-all view of this press. Printing was done under these conditions:

1. A quantity of black ink was added to the press and allowed to distribute. The quantity of ink was such that with the impression to be used, complete solid coverage was obtained.
2. The impression was carefully adjusted to the amount desired by setting the plate height with the adjustment feature on the press and by carefully adjusting the packing. (The plate height adjustment feature is a distinct advantage of this press. It allows raising or lowering of the bed so that the height of the plate can be set very accurately.)
3. The printing speed for each print was recorded.
4. The plate was cleaned after each print and reinked.
5. The time interval between prints was constant.
6. Mechanical conditions of the press were checked and proper settings were made before the test.
7. The paper to be printed was weighed immediately before and after printing with a Mettler balance to the nearest 0.0001 g.
8. A series of 20 prints was made without renewing ink to the system.

A series of prints was obtained which varied slightly in the coverage of the solid printed area from complete coverage to very many unprinted spots. What was of particular interest was not the weight of ink on each print, but the amount of breakup on each print.

This series of prints was analyzed as follows:

1. The unprinted spots on each print were counted by two persons in separate evaluations. Each person counted the spots twice.
2. Four optical instruments were used and the light reflected from each print in the printed area as measured by the instrument was recorded. The four instruments were the Photovolt reflection meter used with the opacity search unit, the Bausch and Lomb Opacimeter, the Gardner automatic color difference meter, and the Beckman Model B spectrophotometer. Many different readings were made on each print depending on the size of the spot inspected by the instrument. The readings were averaged for each print. The instruments were used with standards and were adjusted for maximum sensitivity.
3. The prints were ranked visually and independently by three judges, all of whom were experienced proof press printers.

The rank correlation coefficient between visual ranking and the spot count was determined and found to be 0.99, with 1 being perfect. The Model B spectrophotometer with a reflection head gave the best agreement between spot count and instrument readings, but there was a lot of mixing, particularly at complete coverage or close to complete coverage. That is, it was found that a straight line relationship existed between the readings and spot count as indicated by a correlation coefficient of 0.88, but the deviation from the line

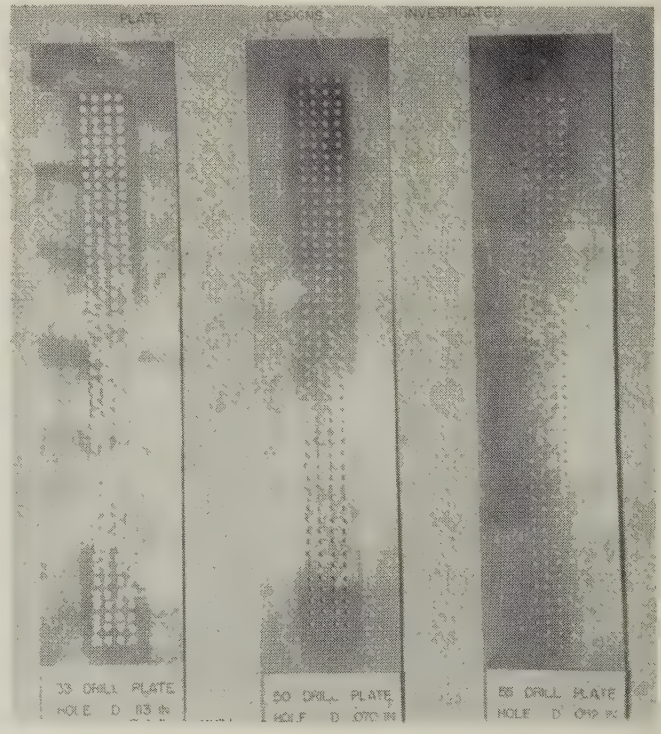

Fig. 2

was quite large, particularly at close to complete coverage. The Model B with reflectance accessory is designed to measure reflectance of opaque solids, liquids, and powders. It measures color. However, its readings are not influenced to the extent desired by a small unprinted spot in the area inspected.

It was, therefore, decided to try a new approach. Since the number of unprinted spots was the main interest and they could all be counted, why not use a thin metal plate with a series of holes in it and inspect the print through the holes? This would reduce the amount of counting that had to be done and the number of spots in the holes probably would represent the total number of unprinted spots if the plate was properly designed. With this in mind, perforated plates were made from 0.003-in. shim stock and each plate had a total of 200 holes drilled in it. As indicated in Fig. 2, different sized holes were drilled in each plate.

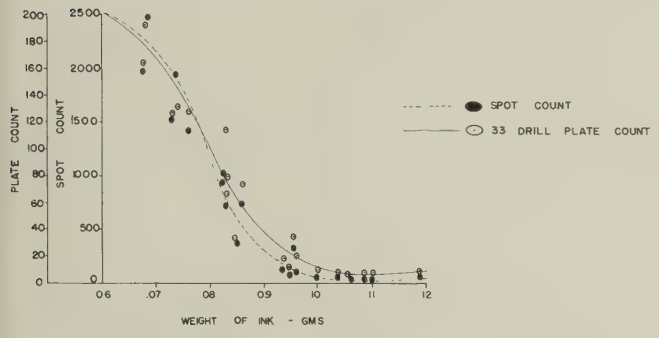

Fig. 3. Relationship between spot count or plate count and weight of ink Vandercook prints; bond control paper

Figure 2 also shows the register system used to check the reproducibility of count. There is an extra hole near the bottom of the plate which corresponds with the visible hole near the top. The sample to be inspected was punched and then pinned under the plate using the register holes. This allowed replacing the sample in the same position as used originally so that the same number of spots would be visible. In this way, the reproducibility of count on a sample could be determined for each operator, as well as between operators.

After considerable experimenting, it was found that a number 33 drill was the most desirable. This drill makes a hole which is 0.113 in. in diameter, so with a total of 200 holes, an area of about 2 sq. in. was being inspected. This is about 9.5% of the area printed.

The same series of prints that was checked with optical instruments was also inspected with this perforated plate. If there was one or more unprinted spots in a hole, it was given a count of one. Since there were 200 holes in the plate the maximum count that could be obtained was 200. Figure 3 is a graph of the plate count and the spot count as the ordinate versus the weight of ink on each print as the abcissa. Note the different scales. The relationship between the plate count and the spot count is excellent. Figure 4 is a graph of the plate count and the spectrophotometer readings versus the spot count for the same series of prints. Note the straight line relationship in both cases, but also the large deviation from the line for the spectrophotometer readings and the small deviation for the perforated plate count, particularly over the range of low spot count. Generally, then, as indicated by this graph, the perforated plate count is directly related to the spot count. A correlation coefficient of 0.98 was obtained. Sensitivity of the plate count to changes in the number of unprinted spots is very good as indicated by the slope of the straight line.

The reproducibility of count for a given print is good, but it depends on the magnitude of the count. The graph of the standard deviation of the count versus the magnitude of the count from 0 to 200 is a parabolic curve and the deviation reaches a maximum at a count of 100. This maximum deviation is within the limits of satisfactory reproducibility.

Therefore, the perforated plate meets the three main re-

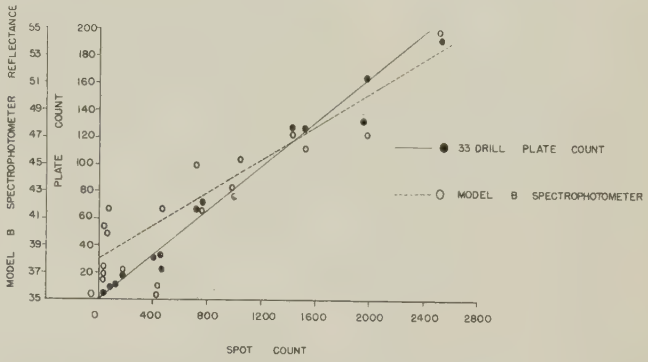

Fig. 4. Instrument studies; Vandercook prints; bond control paper

quirements for a satisfactory test for objectively evaluating solid coverage quality:

1. Agreement between plate count and both spot count and visual ranking is excellent.
2. Sensitivity to changes in spot count is good.
3. Reproducibility is satisfactory.

APPLICATION

Now that a satisfactory technique has been developed for determining what has been defined as solid coverage quality, how should it be used to obtain valuable information? As an illustration of an application, two samples of paper, both for the same end use, and reputed to differ in solid coverage print quality were tested. Before the development of the perforated plate for analyzing quality, these papers were printed and it was found that the prints differed slightly in solid coverage quality when judged visually. However, it

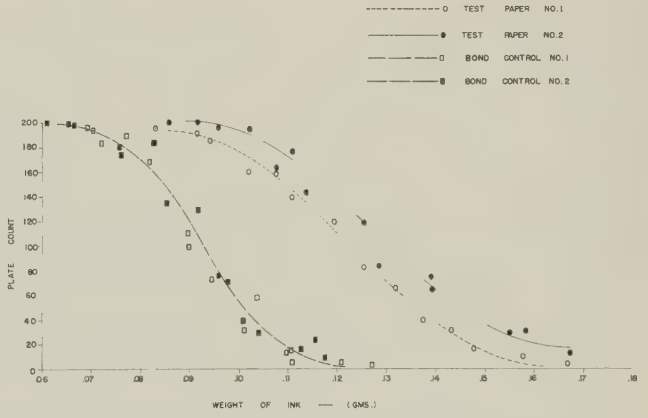

Fig. 5. Plate count versus weight of ink Vandercook prints —0.005 imp. two independent print tests

was not possible to define the difference numerically, and, therefore, the differences could not be described objectively.

These two papers were printed in separate runs on the press so that a series of prints was obtained in which the solid coverage varied from good to poor. Only the top side was printed. For each press trial, alternate prints were made on

bond control paper. The control was picked because it was found to require about the same amount of ink for solid smooth curve. Note the difference in the position of the curves for the two papers. The curves for each of the impressions used generally have the same shape as those in Fig 5. These curves which are essentially sine

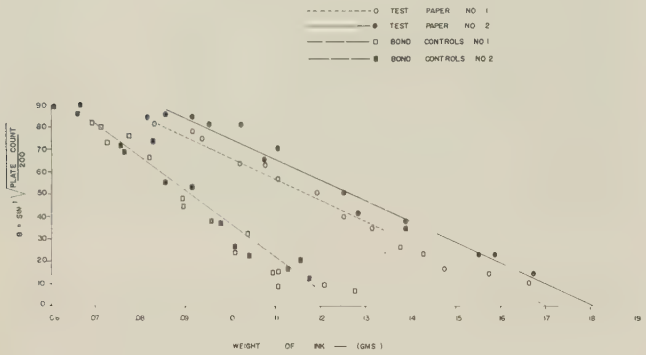

Fig. 6. Plate count as a sine function versus weight of ink

waves can be transformed into a straight line by plotting the angle whose sine is equal to the square root of the ratio of the plate count to 200 as the ordinate versus the weight of ink as the abcissa. This is shown in Fig. 6. The advantage of this graph is that extrapolation to zero plate count or complete solid coverage is simplified. This information was obtained for each of the four different amounts of impression used for testing so a family of curves was obtained.

Figure 7 is a graph of impression versus weight of ink for a given solid coverage quality which in this case is at a perforated plate count of 20. Any other count could have been chosen. This graph illustrates the effect impression has on the weight of ink required for a given solid coverage quality for each of the three papers tested. The differences in the way the papers respond to different press conditions is illustrated.

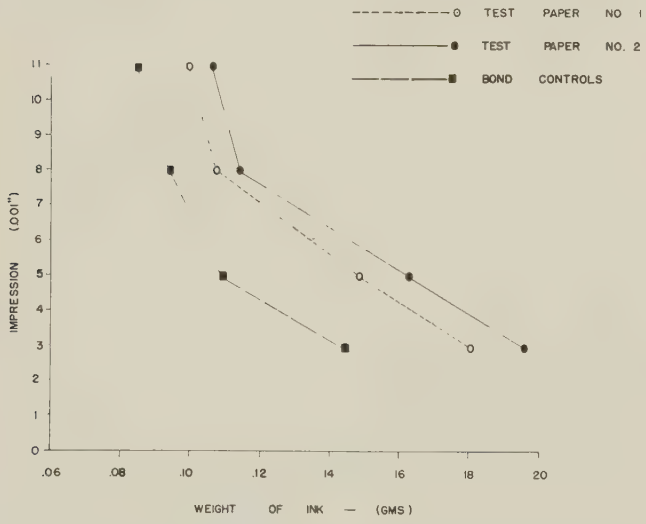

Fig. 7. Impression required at various weights of ink for for a constant solid coverage quality plate count of (20)

Test paper no. 2 required about 10% more ink than paper no.1 at 0.003 in. impression and 5% more at 0.011 in. impression.

The fact that paper no. 2 requires 10% more ink than paper no. 1 at 0.003 in. impression has some important aspects. To obtain this 10% difference on the paper, about 10% more ink will be required on the plate. Therefore, when both papers are printed with the minimum amount of ink for complete coverage, the extra ink required on paper no. 2 will result in more squeeze-out around the outside of type and dots and more fill-up in the bowls of fine type, which means that fidelity suffers. Then too, it is known that for a given grade of paper, showthrough will increase as the amount of ink on the print increases. Therefore, paper no. 2 will have slightly more showthrough than paper no. 1 for these printing conditions. The response of these two papers to press conditions is such that if they are used interchangeably on a job, the printer will obtain the best uniformity of results by printing with the maximum impression tolerable.

Figure 8 is a graph of impression as the ordinate and solid coverage print quality as the abcissa for a given weight of ink. This graph illustrates the effect of impression on print quality for a constant weight of ink. Note again the differences in the way the papers respond. At this constant weight of ink, the solid coverage quality can vary from good to poor depending on the impression used for printing.

This is the extent to which this technique has been used.

FUTURE PLANS

Plans for the future, based on these preliminary findings are:

1. Equations will be developed to describe the results illustrated, and the functions in the equations will be related to physical properties of the paper.

2. The method described will be used to study the response of other papers, particularly coated papers, to press conditions. A study of the physical properties of coated paper which affect the response will be attempted.

3. An attempt will be made to establish a routine control print test method based on the results found by this technique.

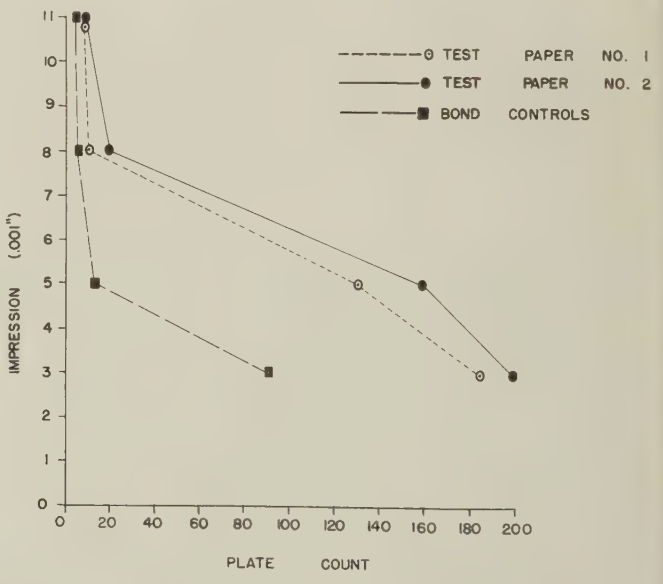

Fig. 8. Impression required for various plate counts at a constant weight of ink 0.1150 g. of ink on paper

4. Using this technique, the response of paper on other printing presses will be studied. It can then be determined whether duplication can be obtained on different presses and the printing conditions for each press which will be most likely to give duplication of results. By so doing, it can be determined whether or not a simple printing press like the I.G.T. printability tester can be used for routine control testing, and the conditions under which it should be operated to give results which are found to correlate with more elaborate presses.

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CONCLUSIONS

Three general conclusions may be drawn from the results obtained:

1. A sensitive, reproducible technique has been developed for objectively determining one aspect of solid coverage print quality of paper.
2. Using this evaluation technique, it is possible to objectively determine the response of paper to any letterpress printing conditions.
3. The uncoated papers studied respond differently to different printing conditions. Generally, the minimum amount of ink required for complete coverage is dependent upon the printing impression.

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May 25–27, 1959

The Bleaching of Eucalypt Kraft Pulp at the Maryvale Mill of Australian Paper Manufacturers Ltd.

W. H. ALGAR, N. W. HANSEN, and K. LINKE

THIS paper sets out to describe the present equipment and process used by Australian Paper Manufacturers Ltd. to produce bleached pulps of G.E. brightness 60, 76, and 81% from eucalypt kraft wood pulp. Present annual production of the three bleached grades by the process is 5700, 7000, and 6300 long tons, respectively.

The bleach plant is located at the Maryvale pulp and paper mill in Victoria, and supplies the three grades of bleached pulp as required to the company's mills in the mainland states.

Commercial bleaching of eucalypt kraft pulp at A.P.M. Ltd. started in 1940 and substantially the whole production of bleached pulps is consumed by the company's paper and paperboard machines as part furnish, along with imported bleached sulphites and krafts, in various white products. Recently, small quantities of bleached eucalypt pulp have been sold to other paper companies operating in Australia. The demand from these sources and from our own mills, ever since bleached pulp production started, has been for higher brightness with maintained strength so that more local eucalypt pulp can be included in paper furnishes. To this end, the production of bleached eucalypt pulps in the brightness range 85 to 90% is at present being investigated on both the laboratory and mill scale.

The current two-stage batch bleaching process uses a combined calcium hypochlorite-chlorine gas first stage followed by a combined sodium hydroxide extraction-calcium hypochlorite second stage (HC-EH) and was introduced for the three grades of bleached pulp in July, 1956. Before going into details of the process and its development it is relevant to briefly review the processes which preceded the present one:

Brightness 60 pulp: Originally made to a lower standard of brightness by a single-stage calcium hypochlorite process. This was followed later by a two-stage hypochlorite process; a two-stage process with combined hypochlorite-chlorine first stage and hypochlorite second stage; and finally the HC-EH process.

Brightness 76 pulp: As brightness requirements have altered over the years so the process has changed through two-stage hypochlorite; chlorine first stage, hypochlorite second stage; three-stage hypochlorite; combined hypochlorite-chlorine first stage, hypochlorite second stage; and finally the HC-EH process.

Brightness 81 pulp: This grade was introduced in July, 1954, using a three-stage process, combined hypochlorite-chlorine, sodium hydroxide extraction, hypochlorite. Later, the HC-EH process was found to be suitable for this grade with the major advantage of higher production rate from the batch system.

EUCALYPT KRAFT WOOD PULP

Some 70,000 tons per year of unbleached eucalypt kraft are prepared from a wood furnish of approximately 40% *E. regnans* and 60% other mixed eucalypt species. The moisture-free value and density of the wood chips are approximately 62% and 34 lb. (moisture-free) per cubic foot (green), respectively.

Typical cooking conditions of: $14^3/_4$% active alkali as Na_2O, 21% sulphidity, 80 p.s.i. pressure, $1^1/_2$ hr. time to pressure, $1^1/_2$ hr. time at pressure give an accepted pulp yield of approximately 48% (moisture-free basis) and the following properties are representative of current production.

Permanganate no.	13–15
Lignin*	1.5–2%
Xylan†	19–20%

* T 222 m-54: Preliminary extraction with 0.5% NaOH instead of alcohol-benzene solution.
† T 19 m-50: Calculated as xylan.

Table I. Physical Properties of the Unbleached and Bleached Eucalypt Pulps

Values interpolated at 250 ml. Canadian standard freeness from Lampen mill evaluations. Laboratory bleached pulps made by the HC-EH process

	Unbleached ex mill	*G.E. Brightness, % 60*	*G.E. Brightness, % 76*	*G.E. Brightness, % 81*
Mill revolutions	7,640	22,400	18,750	17,000
Tear factor	112	108	102	89
Breaking length, km.	9.6	9.0	8.9	8.9
Stretch, %	3.6	4.8	4.4	3.2
Burst factor	68	64	61	61
Bulk	1.56	1.46	1.48	1.45
Air resistance, sec./100 ml.	37	46	39	37
Fold, M.I.T., 1 kg. load	127	129	104	85

Lampen mill operated at 250 r.pm., 25°C., 3.6% m.f. stock concentration (3.0% for unbleached). Sheets made with standard British equipment to basis weight 60 g./sq.m.
Standard British test units as defined in "Second Report of the Pulp Evaluation Committee to the Technical Section," page 97, London, The Paper Makers' Association of Great Britain and Ireland, July, 1936.

Physical properties interpolated from evaluation of the pulp in the Lampen mill are shown in Table I.

After washing, the pulp passes through knotters and is screened through Trimbey-type centrifugal screens with 0.035 to 0.040-in. holes. Pulp for the bleach plant is further screened through 0.008 to 0.010-in. flat screens. The pulp is deckered to chests at 3.5% stock concentration and pumped to the paper mill, Kamyr lap machines, and bleach plant as required.

The quantity of unbleached pulp converted in the bleach plant annually is approximately 20,000 tons.

It will be noted that, except for an additional screening stage, pulp for bleaching is taken from normal production. Laboratory work (Table II) indicates that higher unbleached and bleached pulp yields and better quality bleached pulps are obtained by cooking to a higher permanganate number of 17–19.

Other laboratory work indicates that permanganate number 17–19 pulp from the present wood furnish is the optimum for subsequent bleaching operations. The effect on pulp and paper mill operations of making this grade of pulp as normal production is presently being studied.

BLEACH PLANT EQUIPMENT

There has been no major change to the bleach plant equip-

Table II. Effect of Permanganate No. of Unbleached Pulp on Yield and Physical Properties of Unbleached and Bleached Pulps

Values interpolated at 250 ml. Canadian standard freeness from Lampen mill evaluations. Laboratory prepared pulps bleached to G.E. brightness 82 by HC-E-H process

Permanganate no.	*Unbleached 13.2*	*Bleached*	*Unbleached 17.8*	*Bleached*
Yield, % on moisture-free chips	47.8	46.3	50.4	47.1
Mill revolutions	7,500	18,700	5,800	15,500
Tear factor	119	102	108	104
Breaking length, km.	10.6	9.4	10.4	10.1
Burst factor	71	62	73	74

W. H. ALGAR and N. W. HANSEN, Research Chemists, K. LINKE, Mill Chemist, Australian Paper Manufacturers Ltd., Melbourne, Australia.

ment since it was installed in 1940 as a two or three-stage $5^1/_2$ long tons batch plant.

Briefly, (a) A Pulp Bleaching Corp. vertical batch chlorinator with draft tube and propellor to circulate stock at 3.5% concentration, with provision for direct injection of chlorine gas at the base of the draft tube.

(b) Stock from the chlorinator is pumped either direct or via a chest to an Oliver high density thickener (unfortunately not completely acid resistant).

(c) Thickened stock (14%) is shredded on to a rubber conveyor belt which delivers to any of three Pulp Bleaching Corp. tile lined cookers each fitted with a screw-in-tube central mixer and plough. Steam and water inlets are provided in the base.

(d) Cookers dump to a chest after dilution and the stock is pumped to the thickener and returned to another cooker if a third stage is required. For a two-stage process, stock may be acidified in the chest and pumped to an Oliver washer, which delivers to another chest. The bleached stock is pumped to the Kamyr lap machines or the paper mill. The bleached stock is not screened.

(e) The bleached pulp is dispatched in bales of either wet lap (55% air-dry) or Flakt dried lap (85% air-dry).

Since October, 1954, the company has operated at Maryvale a mercury cell electrolytic plant which supplies the whole of the chemicals required by the bleach plant, namely, chlorine, sodium hydroxide, calcium hypochlorite liquor (lime from the pulp mill) and sulphuric acid (spent acid from the chlorine drier).

THE HC-EH PROCESS

The HC-EH process is now used for all three grades of bleached eucalypt pulp, the required brightness being obtained by varying the amount of available chlorine used in each stage. Typical mill bleaching schedules are shown in Table III.

Available chlorine applied in the first stage is determined by the operator from the product of a factor by the bleachability of the unbleached pulp (permanganate number of stock from the chlorinator without further washing). The stock concentration of each batch (constant volume) is also determined.

The first stage uses calcium hypochlorite liquor and chlorine gas in the chlorinator in the ratio of 80:20. The hypochlorite is allowed to react for 10 to 20 min. then chlorine is added as rapidly as possible and allowed to react until almost exhausted. The final pH is between 4.5 and 5.

After washing with filtered water on the thickener the thickened stock enters a cooker for the second stage, which is a combined mild alkali extraction and hypochlorite bleach. Sodium hydroxide solution and direct steam are added during the filling of the cooker at such a rate that the required temperature is reached, and amount of alkali is added, by the time that the cooker is full. The charge is mixed for 20 to 30 min. then calcium hypochlorite liquor added without intermediate dilution or washing. The batch is diluted with filtered water and dumped to a chest when the pH falls to 8 to 8.5. A small amount of available chlorine still remains at this stage.

Table III. Details of Present Bleach Plant Processes

Combined hypochlorite-chlorine first stage, combined extraction-hypochlorite second stage

G. E. brightness grade, %	*60*	*76*	*81*
Stage 1:	3–3.5% stock concentration. Temperature as received (20–30°C.)		
Available chlorine, % on a.d. unbleached pulp	$2^1/_2$–3	$3^1/_2$–4	4–$4^1/_2$
	80% as calcium hypochlorite for 10–20 min., then 20% as chlorine gas		
Total bleaching time, minutes	50–60	60	60
Final pH	4.5–5	4.5–5	4.5–5
	Washed and thickened over thickener		
Stage 2:	12–13% stock concentration		
Sodium hydroxide, % on a.d. unbleached pulp	0.4	0.5	0.7
Temperature, °C.	30	40	40
Extraction time, min.	20–30	20–30	20–30
Calcium hypochlorite, % available chlorine on a.d. unbleached pulp	$^1/_2$–1	$^3/_4$–$1^1/_4$	$1^1/_4$–$1^3/_4$
Bleaching time, min.	60	120	120
Final pH	8–8.5	8–8.5	8–8.5
	Diluted to 3% stock concentration in agitated chest. Sulphuric acid added to pH 5.5–6. After 15 min., washed		

Sulphuric acid is added to the stock in the chest to bring the pH to 5.5 to 6 for 15 min. before final washing with filtered water and lapping.

Chemical requirements of the HC-EH process are compared with some of the earlier processes in Table IV.

The lower total quantity of available chlorine necessary to achieve a given brightness level and the higher proportion of available chlorine used in the first stage of the HC-EH process will be noted.

Physical properties of the three grades of bleached pulp made by the HC-EH process can be compared with unbleached pulp properties by reference to Table I. The values are typical of the bleached grades irrespective of the various processes shown in Table IV.

COMBINED HYPOCHLORITE-CHLORINE STAGE

The combined hypochlorite-chlorine first stage was introduced as a result of laboratory work on the acidified hypochlorite process described by Giertz (*1*). During kraft cooking, lignin-hemicellulose complexes may be formed to such an extent that the chlorine reaction with lignin in the bleaching

Table IV. Chlorine and Sodium Hydroxide Requirements of the Various Processes

Six-months' plant operation. Average figures adjusted for bleachability

G.E. brightness grade, % process	*60*			*76*			*81*	
	H-H	*HC-H*	*HC-EH*	*H-H-H*	*HC-H*	*HC-EH*	*HC-E-H*	*HC-EH*
Total available chlorine, % on a.d. unbleached pulp	3.8	3.6	3.4	6.2	5.7	4.9	6.4	5.7
Available chlorine, % of total in first stage	63	76	79	49	69	77	72	75
Ratio of hypochlorite/chlorine in first stage, %	...	60:40	80:20	...	60:40	80:20	60:40	80:20
Total sodium hydroxide, % on a.d. unbleached pulp	...	1.5[a]	0.4[b]	...	2.1[a]	0.5[b]	3.2[c]	0.7[b]

[a] All used to adjust first stage to pH 8 to 9 before thickening.
[b] All used in second stage.
[c] Includes 1.2% used to adjust first stage to pH 5 to 6 before thickening.

process is retarded. Improved lignin removal can be obtained by a preliminary mild oxidation with hypochlorite (*2*).

Laboratory experiments on eucalypt kraft pulps showed that more available chlorine can be usefully consumed in attaining greater delignification of the pulp in a single-stage bleach with acidified hypochlorite than with either chlorination or hypochlorite treatment, other conditions being constant. The increased delignification by the acidified hypochlorite process is achieved without severe attack on the cellulose, apparently due to two features: (a) the initial hypochlorite treatment, although not removing very much lignin, modifies the remaining lignin to render it more reactive in the subsequent chlorination; (b) the liberation of chlorine within the fibers on acidification increases its rate of attack on the lignin.

While the acidified hypochlorite process using a mineral acid as the acidifying agent was not economically attractive in the existing batch plant, it was found that some of the advantages of the process could be gained using chlorine gas for acidification.

The first mill application of the process in August, 1952, used a 40:60 distribution of hypochlorite-chlorine to give a final pH of 2 to 2.5, but because the thickener is not acid resistant it was necessary to neutralize the first stage stock with sodium hydroxide to pH 8 to 9 (later reduced to pH 4.5 to 5) immediately before thickening. Subsequently, the ratio of hypochlorite to chlorine was increased through 60:40 (at the time of a shortage of chlorine) to the present 80:20 distribution which, with a final pH of 4.5 to 5, eliminates the need for neutralization. There was an over-all saving in cost of chemicals and no adverse effect on the quality of bleached pulp from the HC-EH process.

Work on an HC-E-H process showed that a pH higher than 3 in the chlorination part of the first stage would be likely to lead to degradation of pulp during bleaching. However, the success of the HC-EH process, with a reaction pH of 4.5 to 5 in the first stage, can probably be explained by the difference in alkali treatment in the second stage. In preliminary work on an HC-E-H process with pH above 3 in the first stage, this was followed by a relatively severe hot alkali extraction (1.8% NaOH (air-dry basis), 60°C., 1½ hr.) which may have degraded the "potentially degraded" pulp from the first stage (*3*). The HC-EH process uses a much milder alkali treatment in the second stage (0.5% NaOH (air-dry basis), 30 to 40°C., 20 to 30 min.) which probably permits more tolerance in the first stage pH without having so much effect on final bleached pulp strength properties.

Although a two-stage process using an HC first stage was originally developed to replace the three-stage hypochlorite process used for brightness 76 pulp, its application was soon extended to the brightness 60 grade. When production of brightness 81 pulp started, the new stage was incorporated in a three stage HC-E-H process using the 40:60 distribution in the first stage.

COMBINED EXTRACTION-HYPOCHLORITE STAGE

The combined extraction-hypochlorite stage was first introduced for the brightness 76 grade during July, 1956. The process previously used was a combined hypochlorite-chlorine first stage, adjusted to pH 8 to 9 before dumping to avoid thickener corrosion, followed by a hypochlorite second stage.

It is well known that increased sodium hydroxide buffering in a hypochlorite stage is beneficial to bleached pulp quality. It was established that the pH adjustment made after the first stage to avoid thickener corrosion was unnecessarily high and that a pH of 4.5 to 5 would serve to avoid excessive corrosion. The sodium hydroxide saved from the first stage was then available to provide additional buffering in the second stage.

Table V. Effect of Second Stage Extraction Time on Properties of G.E. Brightness 57 Pulp

Values interpolated at 350 ml. Canadian standard freeness from Lampen mill evaluations. Mill bleached pulps made by HC-EH process

Extraction time, min.	*30*	*90*	*120*	*Unbleached*
Tearfactor	116	106	114	112
Burst factor	66	59	56	66

A thought of using the sodium hydroxide to give the pulp a mild extraction to dissolve chlorinated lignin from the washed first-stage pulp, before making use of the same hydroxide as a buffer for the hypochlorite, started a new investigation from which developed a combined extraction-hypochlorite stage without intermediate dilution or washing.

The combined extraction-hypochlorite stage differs from the commonly used buffered hypochlorite stage in which the buffer is added during the bleaching or with the bleach liquor in order to keep the pH above the degrading pH 6 to 8 zone. With prior addition of buffer, as in the EH stage, a period at a moderate temperature is allowed for solution of water-insoluble chlorinated lignin before hypochlorite is added. At the same time, having the pulp well mixed with alkali before adding the bleach liquor no doubt assists in avoiding local rapid overbleaching before all the bleach liquor is uniformly mixed with the pulp. This applies particularly to brightness 60 pulp where the quantity of bleach liquor used in the second stage is relatively small.

With regard to the time allowed for extraction, Table V shows that longer times than the 20 to 30 min. now used give a final bleached pulp with reduced bursting strength. On the other hand, shorter times give, in the case of brightness 60 pulp, incomplete bleaching of small dark shives which may be present in the unbleached pulp.

Because the chlorinated lignin dissolved by the sodium hydroxide is not washed from the pulp before the hypochlorite is added, the combined EH stage requires higher chemical usage than the conventional E-H stages when applied to high lignin content pulps, such as long fiber kraft and high yield kraft pulps, but is far more economical for bleaching present quality eucalypt kraft in a batch plant, particularly to brightness levels around 80%.

The new HC-EH process was found to produce brightness 60 and 76 grades at lower cost than the processes previously used with a slight benefit in final bleached pulp strength. In the case of brightness 81 pulp the HC-EH process replaced a three-stage HC-E-H process with resultant savings in chemicals, increase in production rate and no adverse effect on bleached pulp strength.

FUTURE DEVELOPMENTS

The limitations of the existing bleach plant equipment have made compromises necessary in applying the principles of the HC and EH stages to plant operation. To suit the equipment and to attain the required production rates it has been necessary to modify the process specified by laboratory work. The challenge presented by the present plant has certainly stimulated research on bleaching, and the indicated future demand for brightness 85 to 90% eucalypt pulps is a problem now being tackled.

For the production of brightness 85 eucalypt pulp, laboratory work shows that a three stage process using a combined hypochlorite-chlorine first stage, a combined extraction-hypochlorite second stage and a buffered hypochlorite (or extraction-hypochlorite) third stage is suitable. Such a process yields bleached pulp of similar strength properties to that obtained from a conventional four-stage process, e.g., HC-E-H-H.

The production of pulps in the brightness 88 to 90% range is also being investigated.

SUMMARY

The present equipment and process used for the production of G.E. brightness 60, 76, and 81% bleached pulps from eucalypt kraft wood pulp at the Maryvale mill of Australian Paper Manufacturers Ltd. is described. The three grades of bleached pulp are made by a two-stage batch process (HC-EH) using a combined calcium hypochlorite-chlorine gas first stage and a combined sodium hydroxide extraction-calcium hypochlorite second stage. The development of these combined stages is discussed. The main advantage of the process lies in increased production rate from a batch plant when making pulps of brightness around 80%. At this brightness level the two-stage HC-EH process replaces a conventional three stage process without detriment to bleached pulp quality. Future developments are indicated.

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New Developments in the Manufacture of Synthetic Fiber Paper

HANNS F. ARLEDTER

A PAPERMAKER setting out to formulate a specialty paper is in the same position as an architect designing a building. He has a number of fibers (building blocks) of certain shapes and sizes and his task is to put and hold them together in a structure to serve a particular purpose.

The problem is, therefore, to choose fibers or fiber combinations, cut them to the length the structure requests, disperse them well in water (paper), or air (nonwoven fabric) and deposit the fibers on a screen to form a mat.

Most synthetic fibers, unlike hydrated and fibrillated cellulose, do not fibrillate sufficiently nor bond on drying or with pressure alone, and a water-laid web formed from an aqueous suspension of such fibers has no wet strength "off couch" or during drying of the sheet.

The complex difficulty in making paper from synthetic fibers so far, does arise, therefore, from the necessity to bond the synthetic fibers together in the structure with the most economical and practical binder, and to develop methods to handle the rather weak, wet paper structure on the paper machine until the binder, after drying, takes effect.

The fiber bonding of synthetic fiber papers can be achieved in a number of different ways:

1. Fiber Fusion by Heat and Pressure (*1*). This method requires the use of thermoplastic fibers and requires heat and pressure.
2. Organic Solvent Fiber Fusion (*2*). The fibers usable for this procedure must either swell or dissolve in the solvent.
3. Inorganic Salt Fiber Fusion (*3*). This requires inorganic salts to swell the fiber surface and heat and/or pressure.
4. Fiber Fusion with the Help of Strong Acids or Alkalis (*2*). This is achieved by exposing all or part of the fibers, which are swellable at least on the surface, to acids or alkalis.
5. Fiber Fusion with Water Swellable Fibers (*4*). For instance, polyvinyl alcohol fibers can be manufactured specifically for this purpose.
6. Binder Bonding. This requires the addition of 5 to 40% binder, either by using a solvent system or by employing water dispersion or emulsions.
7. Fiber Floc Bonding (*5*). This is achieved by adding small amounts of highly hydrated and fibrillated suitable cellulosic fibers.
8. Combination of Submicron Synthetic Fibers, Coarse Synthetic Fibers and Binder (*6*).

Many of these methods create a number of inborn problems for the papermaker, either by causing manufacturing difficulties (for instance, insufficient strength during manufacture on the paper machine or lower paper machine speed), or by effecting undesirable binder or bonding side issues (for instance, broke recovery). Most of these methods require also specific manufacturing steps, and none works with the same ease as can be expected from cellulosic fibers. All of them will increase the price of the synthetic fiber paper unduly.

For the binder bonding the following rules apply: "The binder determines the chemical and electrical performance characteristics of the paper," and "The paper is no better than the binder." The author stated in an article (*7*) the following: Probably the most important contribution in any synthetic fiber paper development, if the other problems are solved, is to find the most effective and practical bonding agent for a given paper. The proper binder or binding procedure for any synthetic fiber paper product assumes, therefore, an importance of great magnitude."

This paper presents a new method of synthetic fiber bonding and discloses, a manufacturing method to produce a 100% true synthetic fiber paper with a process closest related to papermaking equipment and methods. The new method allows the manufacture of specific synthetic fiber papers without the use of any binder, solvents, salts or any other chemicals and does yield a great number of specific paper structures of very similar nature as cellulosic fiber papers. The new papermaking method has overcome the problem of insufficient strength of the wet sheet on the paper machine and allows the reuse of wet and dry broke. Synthetic fiber paper made of one fiber class or mixture of two or more fiber systems are feasible, with all the theoretical possibilities deriving from this fact.

The papers described in this article are manufactured by fibrillating fibers, specifically of the nature of acrylic fibers, which were developed by the Chemstrand Corp. in cooperation with Hurlbut Paper Co. This paper discloses only the results presently available for publication.

The history of the manufacture of organic synthetic fibers, which show fibrillating characteristics, is 10 to 15 years old. It was known (Moncrieff *8*) for instance, for quite some time that a continuous filament of Orlon shows, during orientation, the tendency to fibrillate, i.e., each filament tends to divide into many finer fibrils. The development of fibrillating viscose rayon fibers for papermaking started in 1948 by H. F. Shearer (*9, 10*) of American Viscose Corp. Wooding and Woodberry (*11*) of American Cyanamid Co. suggested the use of fibrillating fused polynitrile fibers for fiber forming, laminates, and papermaking in patents published in 1957 and filed in 1953.

HANNS F. ARLEDTER, Director of Research, Hurlbut Paper Co., South Lee Mass.

Table I. Properties of Nonfibrillated and Fibrillated Cotton and Acrylic Fiber Papers

	Cotton fiber paper			*Acrylic fiber paper*	
Degree of fibrillation, freeness in degree Schopper	None	22°S.-R.	36°S.-R.	None	Well fibrillated
Basis weight, 24 × 36-500 lb.	82	84	80	82	84
Thickness, mil	40	13	12	35	14
Tensile strength, g. per in.	None	6000	10,300	None	10,500
Wet tensile strength, g. per in.	...	180	280	...	4000
Bursting strength, lb.	None	20	36	None	28

Table II. Properties of Absorbent Papers Made of Fibrillating Acrylic Fibers Without Any Binders

	0-3233-5	0-3233-2	0-3233-1	0-3239
Basis weight 24 × 36-500 lb.	80	70	60	28
Thickness, mil	16	14	12	7.0
Tensile strength, g. per in.	9800	5600	3600	1800
Tensile strength, lb. per in.	21.6	12.4	8	4
Bursting strength, lb.	23	13	10	4
Klemm test (capillary rise of water in $^1/_{16}$ in. at 60 sec.	11	12	12.5	10

D. C. Nicely of Chemstrand Corp. suggested the development of (acrylic) synthetic fibers with superior fibrillating properties to the author. It is to be noted that the Chemstrand Corp. was able to develop fibers which fibrillate and bond under certain conditions somewhat similar as regular cellulosic papermaking fibers, and Hurlbut Paper Co., after many trials, was successful in rating the many developmental fibers for direct papermaking, "fiber floc" applications, or for uses in combination with nonfibrillating fibers.

We were able to pilot plant produce paper of various design and properties with or without the use of papermaking binders, sizes, fillers, and other additives.

Our survey has indicated that the theoretical possibilities to produce fibrillating or self-bonding synthetic fibers is greater than was indicated at the start of our work to develop synthetic fiber paper of a different nature. We found, for instance, that at least two other fiber groups yield fibrillating characteristics.

The manufacture of the new fibers and papers is still in the developmental stage, but two Hurlbut Paper Co. regular paper machine trial runs have already demonstrated the practical aspect of the new method and it is foreseen that the new papers should be available in production quantities within a reasonable length of time.

Let us compare now the fibrillating behavior of cellulosic cotton fibers and the newly developed papermaker acrylic fibers.

Cotton fibers cut to 1 to 6 mm. length but not fibrillated or beaten and formed to a mat can be made into a paper structure with a similar technique as employed for synthetic fiber paper; however, such an unbonded, unfibrillated cotton paper is extremely weak. On the other hand, the cotton fibers do possess their own binder system, which can be developed by beating, brushing, and fibrillating. The mechanical treated cotton fiber surface and the fibrils do yield a strong bond upon drying.

Table I shows some physical properties of unfibrillated and fibrillated cotton paper and acrylic fiber paper.

Figures 1, 2, 3, 4, 5, and 6 compares photomicrographs of treated and untreated cotton linters and acrylic fibers. Figure 7 shows a nonfibrillating synthetic fiber given the same treatment used to fibrillate the acrylic fibers.

A group of selected fiber micrographs, Figs. 8 to 10, show the degree and the type of fibrillation obtained in the Hurlbut pilot plant. It will be noted that the new fibers in the present state of development show properties which promise a great harvest of new paper materials.

Table III. Properties of Absorbent Papers Made of Fibrillating Acrylic Fibers Containing Binder

Paper grade	0-3236-5	0-2924-2	0-3239-4
Binder	A	P	A
Binder, %	2	6	2
Basis weight, 24 × 36-500 lb.	80	85	30
Thickness, mil	15	16	7
Tensile strength, g. per in.	13500	16000	2900
Tensile strength lb. per in.	30	35.5	6.5
Wet tensile, g. per in.	7000	8000	1700
Bursting strength, lb.	30	40	8

Table IV. Properties of Phenolic Laminates

	Hurlbut developmental paper grade	Commercial paper grade
Fiber type	Fibrillating synthetic fiber	Cotton linters
Resin type	Phenolic D	Phenolic D
Resin, %	48	48
Laminate thickness, mil	66	66
Punchability	Excellent at 80–90°F.	Above 130°F.
Moisture absorption, weight % after 96 hr. in water at 23°C.	0.10	0.42
Volume resistivity, ohm cm.		
As supplied	2.5×10^{14}	1.3×10^{13}
96 hr in water	2.4×10^{14}	9×10^{11}
Insulation resistance, ohm, C/96/90/40	~10,000,000	~200,000

Table II gives some physical strength paper properties of binder-free 100% synthetic fiber paper made of fibrillating acrylic fibers and produced on the 9-in. Hurlbut pilot plant paper machine without the use of any chemicals, additives, or any heat calendering or processing.

Heat calendering of paper grade 0–3233–5 increases the tensile strength to approximately 19,000 g./per in. and more than doubles the bursting strength.

Table V. Influence of Water Emulsion Type Binder P on Electrical Properties of Synthetic Fiber Paper Phenolic Laminates

	Paper without binder	Paper containing approx. 8% binder P	Paper containing 1% binder A
Resin type	C	C	C
Resin, %	52	51	55
Laminate thickness, mil	34	32	35
Moisture absorption, % after 48 hr. in water at 23°C.	0.37	1-40	0.4
Volume resistivity, ohm × cm			
As supplied	3.6×10^{14}	4.6×10^{13}	5×10^{14}
96 hr. in water at 23°C.	1.8×10^{14}	1.3×10^{12}	1×10^{14}

The strength of such papers may be increased, without heat calendering, to a very high level by the addition of small amounts of papermaker binders as indicated in Table III or by adding precut long synthetic fibers.

It will probably take some time until the good strength results obtained with the reported pilot plant papers can be completely reproduced with production machines, but it is already indicated that ultimately equal or better results as listed in the tables should be forthcoming.

Table VI. Properties of LP Laminates Made of Glass, Acrylic Fiber Paper 0-2931-2C and Cellulosic Absorbent Paper

Laminate properties	Polyester laminates made of: Acrylic fiber paper	Glass fiber paper	Cellulosic absorbent paper
Taber abrasion resistance, gram weight loss per 500 cycles	0.30	0.37	0.38
Water absorption 16 sq. in. 16 hr. in grams	0.047	0.068	0.186
Behavior of laminate by impact with hammer	Does not break Does not part	Breaks and parts	Breaks and parts

In our development work we are concerned a great deal with absorbent base papers for the laminating industry.

Table IV shows the electrical properties of the new developmental paper grades in phenolic laminates in comparison with laminates made of cotton linter papers and the same phenolic resin. One of the difficulties of producing electrical grades synthetic fiber papers on a paper machine is due to the fact that nearly all—or most—water emulsion or water solution-type binders reduce the electrical performance characteristics of an electrical clean fiber material. Organic

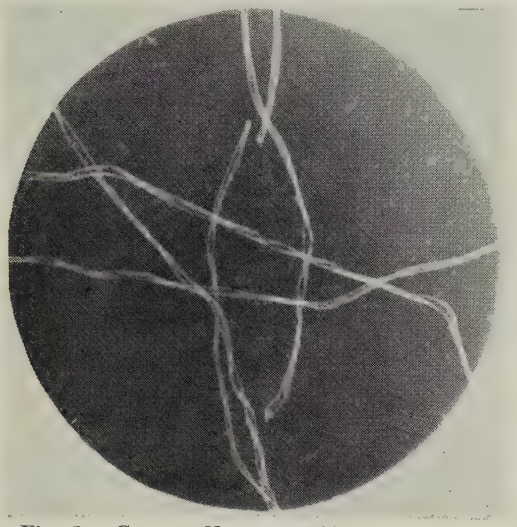

Fig. 1. Cotton fibers not fibrillated. 67×

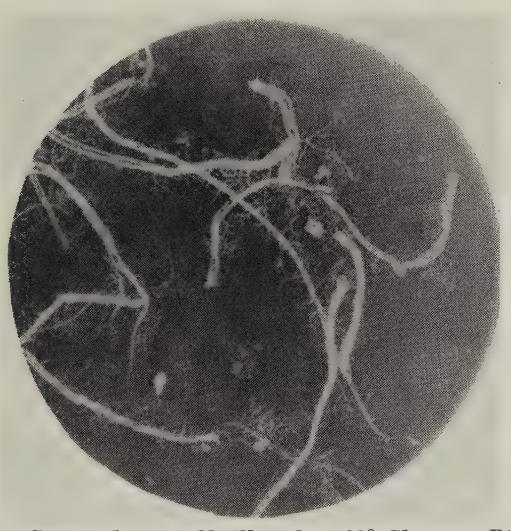

Fig. 2. Cotton linters fibrillated to 22° Shopper-Riegler. 67×

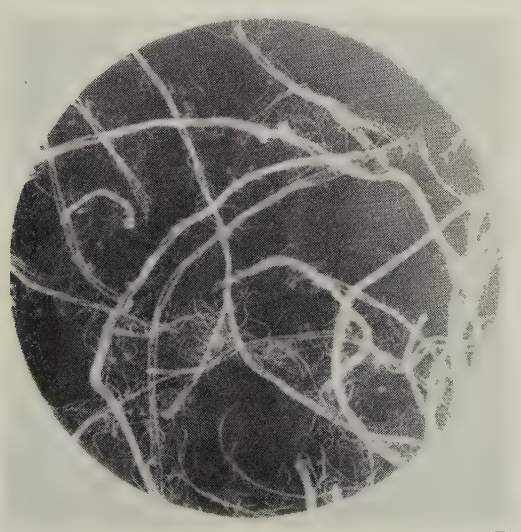

Fig. 3. Cotton linters fibrillated to 37° Shopper-Riegler. 40×

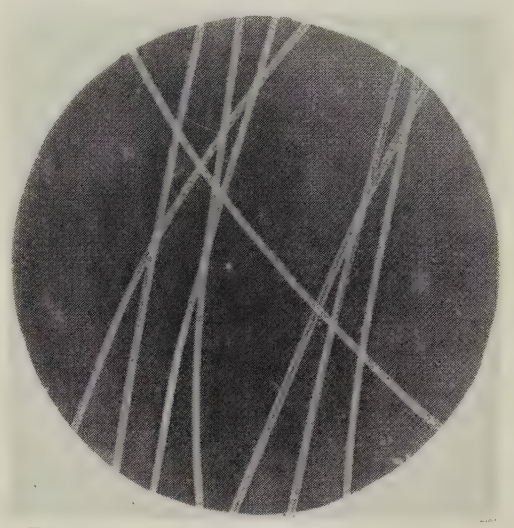

Fig. 4. Fibrillating acrylic fibers before fibrillation treatment. 40×

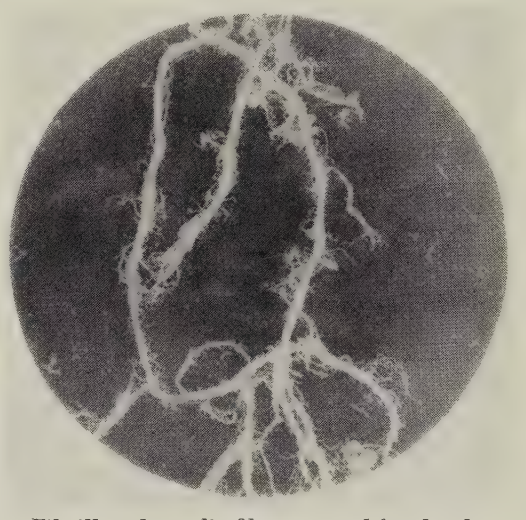

Fig. 5. Fibrillated acrylic fiber as used for developmental paper grade 0-3238. 40×

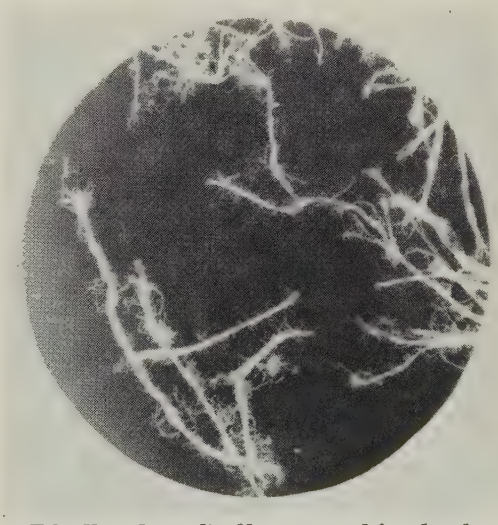

Fig. 6. Fibrillated acrylic fiber as used for developmental paper grade 0-3235. 40×

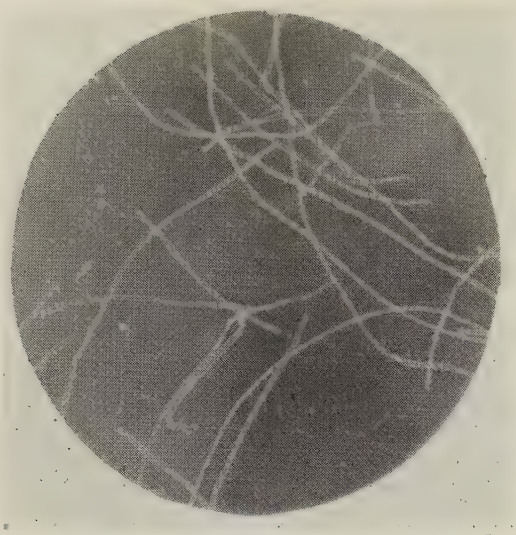

Fig. 7. Nonfibrillating synthetic fibers given the same treatment used to fibrillate acrylic fibers. 40×

Fig. 9. End of a fiber showing fibrillae. 500×

solvent-type binders do not show this deterioration of tests, but such binders cannot be used on conventional paper machines.

The new fibrillating fibers can be manufactured without any binder and the paper shows, therefore, optimum electrical performance characteristics as this can be concluded from Table IV.

Some of the newly developed experimental fiber papers might show interesting aspects as polyester overlays or base paper yielding improved abrasion resistance, reduced moisture absorbency, and excellent chemical and weather resistance. Such paper materials might be useful and interesting as overlay for glass reinforced polyester laminates for improving the resistance to porosity resulting from impact.

Table VIII. Effects of Chemicals on Paper Grade 0-3235-5

Test solution	*Concentration, %*	*Exposure temperature, °F.*	*Exposure time*	*Effect on paper strength (tensile and burst)*
Hydrochloric acid	30	~73	20 days	Very slight or none
Hydrochloric acid	37	~73	2 days	Appreciable loss in strength
Sulphuric acid	60	~73	20 days	Very slight or none
Sodium hydroxide	20	~73	20 days	Strength of paper increases after drying. Weakened in the wet state
Sodium hydroxide	2	212	1 hr.	Swelling and loss in strength of wet paper The dried paper approx. doubles in strength
Sodium hypochlorite	5% Available chlorine	~73	10 days	Slight or none
Hydrogen peroxide	30% H_2O_2	73	10 days	Very slight or none

When for ultimate strength or other reasons some water system binder had to be employed some loss in electrical laminate quality was noted in our lab tests reported in Table V. The new fibers yield higher strength with only small binder additions and reduce, therefore, the deteriorating influence of binder in the paper.

The paper can be printed, impregnates very fast in low pressure resin solutions (2 to 20 sec. versus 200 to 300 sec. for cellulosic absorbent papers) and possesses an exceptionally good LP resin wet-strength (2500 to 8000 g. per in.).

LP laminates made of the developmental paper grade 0–2931–2C show high resistance against breaking and resist-

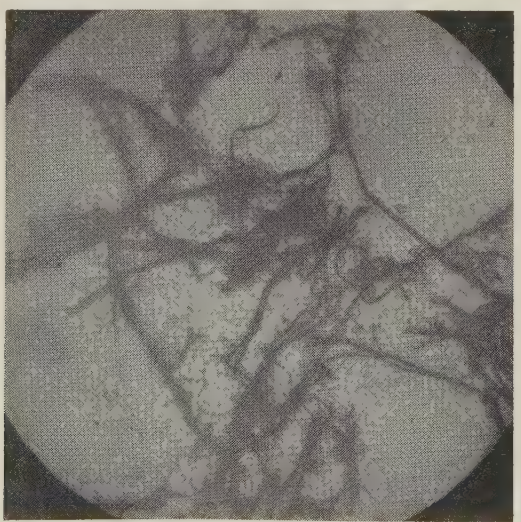

Fig. 8. Well-fibrillated for use as fiber flock. 40×

Fig. 10. Fibers shock by a beater bar. 173×

Table VII. Rapidity and Retention of Quantitative and Qualitative Cellulosic Filter Papers in Comparison with Developmental Acrylic Fiber Papers

Paper grades	*Commercial analytical filter papers A*	*Developmental acrylic fiber paper C-3233-5C*	*Commercial analytical filter papers B*	*Developmental acrylic fiber paper C-2850-C*
Filter grade intended for	For very fine crystals		For moderately fine crystals	
Paper meets the federal retention test for analytical filters UU-P-236 a	100% $BaSO_4$ (hot)	100% $BaSO_4$ (hot)	100% Lead sulfate (cold)	100% Lead sulfate (cold)
% Retention: cold precipitated Ca-oxalate (method 6)	87–97	95.5	51–70	56
Rapidity in sec. (time to filter 10 ml. distilled water)	84–160	76	30–49	30

Results obtained on free hanging cones without suction.

ance against impact with a hammer. A comparison of the LP laminate performance with glass fiber paper and standard cellulosic paper laminates are shown in Table VI. The very good low pressure resin penetration rate of 2 to 10 sec. is noteworthy. The strength of the paper in the low pressure resin solution is also exceptionally good and can be 2000 to 6000 g. per in.

One of the predestined natural applications for the new papers seems to be the field of chemical filtration. The new fibers show excellent acid resistance, good alkali resistance and they are insoluble in all common organic solvents, including acetone, benzene, carbon tetrachloride, dichloroethane, dioxane, alcohol, petroleum ether, solvent naphtha, etc.

7. Flammability. The fibers or papers are not readily ignited and when ignited do not burn rapidly, although the paper does support combustion. The high chemical resistance toward acids and alkali, etc. renders the paper usable for nearly any flameproofing agent.

The intention of the present paper is to acquaint the reader with the properties of papers made of acrylic fibrillating fibers. However, the Hurlbut Research Laboratory has other new developments in the manufacture of organic synthetic fiber papers under consideration which show promise for applications for which acrylic fiber papers cannot be suggested. One development appears to be destined to replace ordinary paper with advantage in all branches of electrical technology.

Table VIIB. Rapidity and Retention of Quantitative and Qualitative Cellulosic Filter Papers in Comparison with Developmental Acrylic Fiber Papers

Paper grades	*Commercial analytical filter papers C*	*Developmental acrylic fiber paper 0-2850*	*Commercial analytical filter papers D*	*Developmental acrylic fiber paper X-922*
Filter grade intended for	For coarse crystals such as silver thiocyanate		For gelatinous precipitates	
Paper meets the Federal retention test for analytical filters UU-P-236 a	100% Retention	100% Retention	100% Retention ferric hydroxide	100% Retention ferric hydroxide
% Retention: Cold precipitated Ca-oxalate (method 6)	12–24	28	7–10	18
Rapidity in sec. (time to filter 10 ml. distilled water)	12–23	17	~5	3

Results obtained on free hanging cones without suction.

It is hoped that the new fibers will permit the production of efficient filter papers for fine crystals to retain barium sulphate precipitated from hot solutions, coarse crystals such as nickel dimethylglyoxime and gelatinous precipitates such as ferric hydroxides.

In choosing the proper fibrillating fiber and the proper manufacturing procedure, filter paper made of 100% fibrillating synthetic fibers for the whole range of analytical filter paper requirements set up for cellulosic paper by the Bureau of Standards could be manufactured.

Table VII compares standard cellulosic analytical filter papers with new pilot plant developmental paper grades.

The papers should be also well adaptable for industrial filter applications. The high wet strength of the papers should prove of specific value.

The following basic properties are wanted for banknote, document, or security paper and are obtained with the new developmental paper grades:

1. Excellent chemical resistance against water, acids, oxidizing agents, alkali and common organic solvents.
2. Resistance against all common mildew, moth, carpet beetle, and other biological agents.
3. The paper stands up well under outdoor exposure and prolonged exposure to sunlight.
4. The age resistance at elevated temperatures up to 200°F. seem to be very good.
5. The fibers used in this paper are of a new and unique nature which should make it more difficult for counterfeiters to reproduce them.
6. The paper prints well.

While the acrylic fiber paper, due to its relatively high price, must be used with discrimination, where its advantages can be fully exploited, the newer paper development will be less expensive and will show good resistance to heat. Newer fiber developments of the nature of polyethylene, polystyrene, polyvinylacetates, etc., are in evaluation and it is hoped that such fibers will find their specific field of applications.

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Presented at the Twelfth Plastics-Paper Conference of the Technical Association of the Pulp and Paper Industry held in Cincinnati, Ohio, Oct. 7, 1957.

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CORRUGATED CONTAINERS SESSION PAPERS

Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry

NEW YORK, N. Y., FEB. 17, 1958

Double Backer Tapered Speed Drive

BURT MENDLIN

When corrugators speeded up more than 350 f.p.m., operators found that they were forced to diminish their glue roll clearances at the double backer glue station to keep the board from becoming excessively wet. The smaller clearances, however, gave them weakly bonded board whenever the machine was slowed for a splice or an order change. In answer to this problem a method was conceived of driving the glue roll in such a manner that as the machine was speeded up, the glue roll speed more closely approached paper speed with consequent less wipe of the adhesive roll by the flutes, and less adhesive pickup. This drive became known as the tapered speed glue roll drive.

The first drive was electronically controlled and was shortly followed by a hydraulically controlled drive and a mechanically controlled drive. The principle of all three drives is identical. Two sources of power are impressed simultaneously on the glue roll. One is in constant ratio to the paper speed; the other is of constant speed independent of paper speed.

The resultant relationship of the roll speed to the paper speed may be expressed thus:

$$r = Rp - B \qquad (1)$$

where

r = roll speed
R = the impressed ratio or ratio
p = paper speed
B = the impressed constant speed or bias

It will be noted that the relationship is a straight line function of slope R and intercept $-B$ so that as valves of p increase the effect of subtracting the bias speed becomes less and less significant. Interpreted in terms of action by the machine, the higher the paper speed the less wiping of the glue roll by the flutes with consequent less pickup of adhesive.

Literature on the tapered speed glue roll drive indicates that the development work was empirical in nature. When it was found that a tapered speed drive tended to conquer the problem of increasing paste application with increasing speed, different values of R and B in equation (1) were tried until a set of conditions was found that yielded a constant paste pattern regardless of speed.

It was suspected that the optimum drive conditions would differ from machine to machine. Theories as to why board became wetter with higher machine speed without tapered speed drive were inadequate to lead to methods of designing a tapered speed drive for a specific machine and its adhesive. Machine manufacturers therefore came out with tapered speed drives in which the ratio and bias could be altered so each plant could, with hunt and try methods, determine the ratio and bias which best suited their particular machines.

This study was begun to find out first, why, without a tapered speed, board becomes wetter with increasing speeds and second, a method whereby a tapered speed drive could be engineered for a specific machine and its adhesive without resorting to expensive and difficult hunt and try procedures.

Burt Mendlin, Asst. Production Manager, Container Div., Cornell Paperboard Products, Milwaukee, Wis.

PROCEDURE

It was reasoned that if board became wetter at higher speeds, it was possible that more adhesive might be available on the glue roll as speeds were increased. This would be in conflict with the age old idea that the amount of adhesive carried on the glue roll was controlled purely by the clearance between the glue roll and the doctor roll, the characteristics of the adhesive being constant.

A simple apparatus, Fig. 1, were constructed to collect the adhesive from the glue roll. By carefully collecting the adhesive for measured intervals of time at different known speeds it was possible to determine the amount of adhesive carried by the glue roll as a function of glue roll speed, keeping the doctor roll clearance and the adhesive characteristics constant. This relationship could be plotted as glue film thickness as a function of roll speed.

By geometrical analysis, it was possible to determine the wiping distance of the flutes on the roll as a function of roll speed and paper speed. Logic indicated that if the volume of glue available to the flute was to remain constant, then the

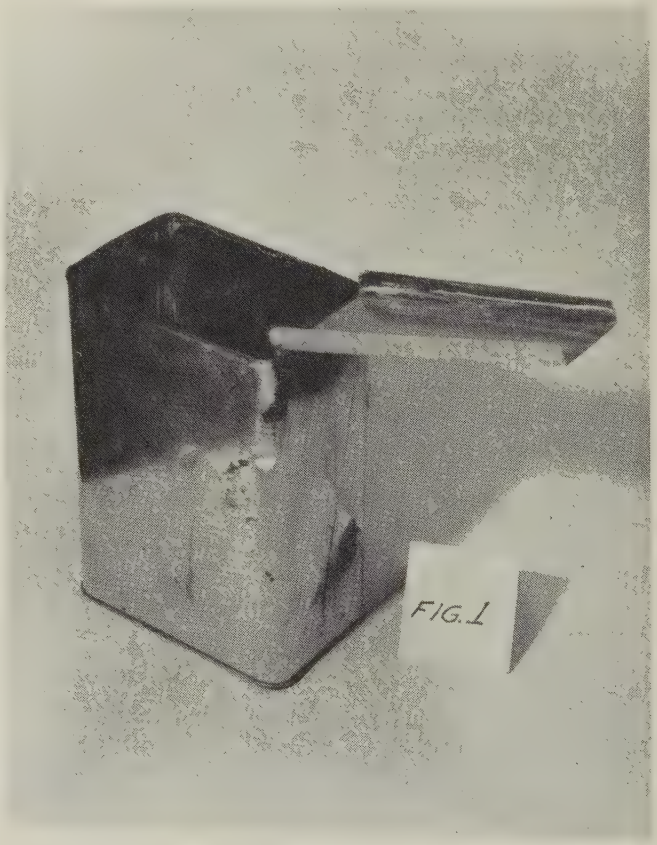

Fig. 1

amount of wipe of the flute on the roll should be proportioned to the glue film thickness so that the product of wipe distance and glue film thickness would be constant.

To determine this constant a speed was selected at which under the machine conditions of the experiment excellent glue pattern was observed.

Mathematically and graphically it was then possible to plot the desired relationship of roll speed to paper speed and determine the ratio and bias which produce the relationship.

CALCULATION OF RESULTS

The film thickness of glue was calculated from the volume collected using the formula for the volume of an annular cylinder and ignoring the second order term of the thickness, namely:

$$V = 2\pi rhf \qquad (2)$$

where:

V = volume of annular cylinder
r = inside radius
h = length of annular cylinder
f = thickness of annular cylinder, film thickness, or outside radius minus inside radius

f was then plotted as a function of roll speed (Fig. 2).

The wipe distance of the flutes was calculated as:

$$w = W - \frac{Wr}{p} \text{ or (4) } w = W\left(1 - \frac{r}{p}\right) \qquad (3)$$

where:

w = wipe distance
W = wrap distance
r = roll speed
p = paper speed

With the objective of having the product of film thickness and wipe a constant, as

$$wf = C \qquad (5)$$

The constant C was determined by choosing the roll speed at which an excellent adhesive pattern resulted and multiplying the film thicknesses at that speed (from Fig. 2) and the wipe distance at that speed (from equation (4)).

With the constant C determined, at 50 f.p.m. roll speed intervals equation (5) was used to determine w at each speed having picked out f for each of those speeds from Fig. 2.

Having w at each speed equation (4) was used to determine the paper speed for the corresponding roll speed.

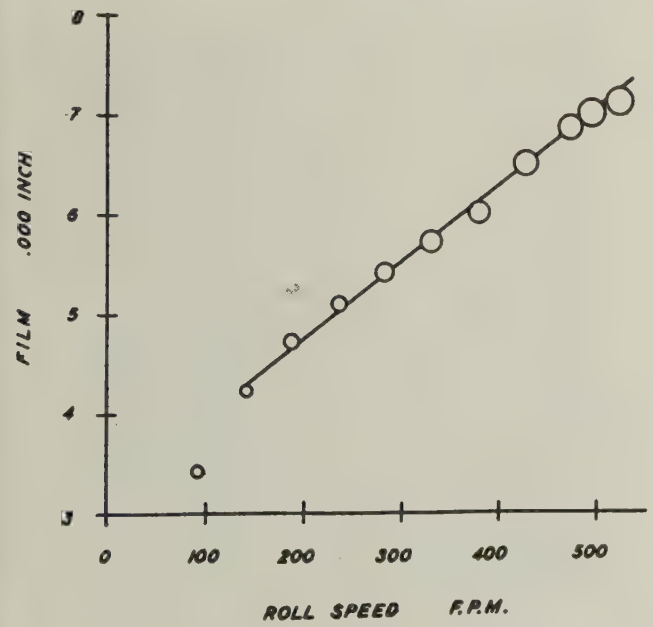

Fig. 2. Effect of speed on film thickness

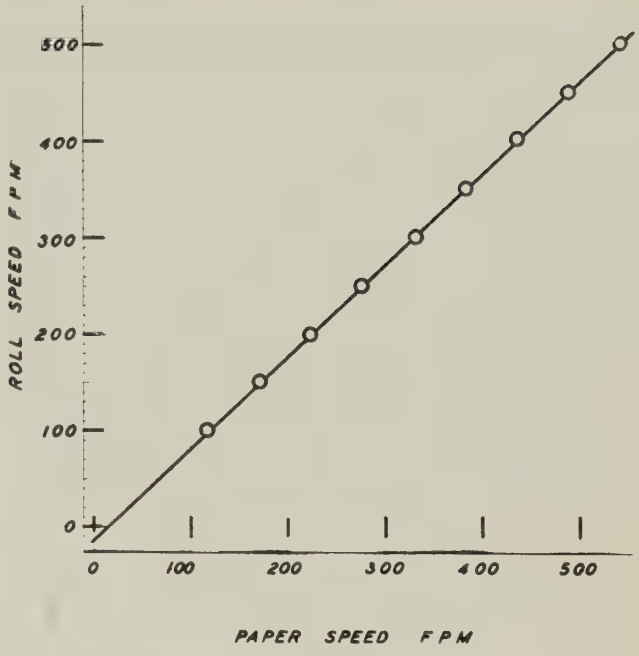

Fig. 3. Calculated tapered speed

Roll speed was plotted as a function of paper speed and is shown as Fig. 3. A straight line of best fit was drawn through these points and the slope and intercept of the line determined.

RESULTS

The results of the determination of glue film thickness as a function of speed are shown in Fig. 2. Not only does the film thickness increase with speed, but it increases at a rapid rate and in an almost linear manner as shown by the line drawn through the experimental points. The size of the points on the graph indicte the extent of experimental error in the data.

Figure 3 shows the relationship of roll speed to paper which satisfies the conditions that the wipe distance multiplied by the film thickness is a constant. The points fall in a straight line of the equation:

$$r = 0.95\,p - 13 \qquad (6)$$

The tapered speed relationship which on the machine under study would produce a constant adhesive pickup at all speeds would have to have a ratio of 95% and a bias of −13 f.p.m.

DISCUSSION OF RESULTS

The change of glue film thickness with roll speed in this study is a fact. The physical phenomenon which causes the fact can be explained in theory.

Adhesive is carried by the applicator to the nip of the applicator and doctor rolls in excess of the amount which passes through the nip. Thus at the nip is a reservoir of adhesive. The two rolls present to this reservoir a Venturi throat. As the adhesive flows through this throat at constant speed a point of low pressure is established in the throat which supplies a driving force for fluid flow in addition to the flow caused by adherence to the surface of the applicator roll. The faster the flow caused by the adherence to the surface of the applicator roll, the greater the pressure differential driving force in the Venturi throat and the greater fluid flow from this driving force. Thus it would appear logical that although the fixed clearance might dictate a constant flow per revolution of the roll because of adherence to the roll, the flow induced by the Venturi effect would increase with increasing roll speed. This phenomenon would

explain the fact of increasing film thickness with increasing roll speed.

The tapered speed relationship of roll and paper with wipe and wrap is a straight mathematical derivation as explained in the calculation of results. It is most interesting to note the part played by wrap in the tapered speed drive.

Realizing that the limit of effective wipe distance is the spacing between flutes, one can see from equation (4) that when the wrap W is large, the wipe w will exceed the spacing between flutes and the effect of tapered speed drive is lost. As an example:

With a wrap $W = 3$ in. and a roll speed to paper speed relationship of 92%

$$w = W(1 - r/p) \qquad (4)$$
$$w = 3\,(1 - 0.92)$$
$$w = 0.24 \text{ in.}$$

Since 0.24 in. is the space between consecutive B flutes, any roll to paper ratio of less than 92% will yield a wipe greater than the distance between flutes. The flute would then move into the track made by the previous flute and not pick up additional adhesive from this additional wipe.

The relationship of wipe and wrap shown in equations (3) and (4) explains why some present users of tapered speed drive claim it works only at higher speeds or complain that at low speeds they still have to open clearances or get a skimpy bond.

CONCLUSIONS AND RECOMMENDATIONS

A tapered speed glue roll drive for the corrugator double backer is a necessity for a uniform glue line at all speeds, because the adhesive film available on an applicator roll increases with increasing speed.

In order for a tapered speed glue roll to be effective at the lower range of speeds, the amount of wrap of the flutes around the applicator roll must be kept below a maximum which can be calculated for any relationship of roll speed to paper speed.

By measuring the adhesive carried on the glue roll as a function of roll speed, it is possible to calculate the desirable tapered speed relationship for that particular machine.

More investigation of this nature should be carried out to determine:

1. The amount of adhesive picked up on the flutes as a function of speed. This can be done by measuring not only the adhesive carried on the glue roll as was done in this study, but also measuring the amount of adhesive remaining on the glue roll after the flutes have traveled over it.
2. The effect on film thickness of adhesive characteristics.
3. The effect on film thickness of roll clearances, roll surfaces, doctor roll speeds, doctor roll locations, and other machine characteristics.
4. The relationship of tapered speed adhesive application and double backer heat and mass transfer with resultant combined board moisture at the corrugator take off.

Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

Nonskid Application on the Corrugators

N. VARNER

Several years ago when box makers spoke of 16 and 30-pt. linerboards,they actually referred to the approximate thickness in thousandths of an inch of 42 and 90-lb. kraft liner. However, the trends toward better printing and box appearance have resulted in a lower caliper and a considerably smoother liner surface. Forty-two-pound linerboard now generally calipers 0.012 to 0.013 in. rather than 0.016 in. as in the past. During the period in which the liner surface was being improved, many advances were also made in handling corrugated boxes, including palletized loading and handling, higher speeds of movement on fork trucks and other conveyors, and higher stacking in warehouses. As a result of the smoother liner finishes and higher speed handling methods, a real problem arose due to slipping and sliding of filled boxes with consequent spilling of loads and damage to the product.

Two or three years ago some of the larger box users began realizing the need for treatment to certain areas of their boxes to prevent slipping and sliding, but still insisted on a slick finish on the side and end panels to give attractive printing. The idea caught on quickly and in a very short time many box makers were being asked by their customers about their ability to supply containers with nonskid properties.

At about the same time a number of chemical and adhesive manufacturers began promoting the virtues of a large number of nonskid coatings, including copolymer resin emulsions, latex emulsions, and colloidal silica solutions. In the meantime many box makers were confronted with the real problem of trying to decide what coating to use, how to put it on the boxes, and how to keep it off their equipment.

There are many variations of nonskid techniques in use today including:

1. Mechanical roughening of the liner of the top and bottom flaps at the corrugator.
2. Applying coatings of nonskid materials to certain areas of the box blanks by means of roller coaters, sprays, or brushes at the corrugators or printing presses.
3. Applying nonskid coatings to the packed and sealed containers in the customers' plants.

Union Bag-Camp's production experience to date in imparting skid resistance has been largely limited to mechanical roughening of the liners and to application of colloidal silica solutions by various roll coating methods at the corrugators. However, consideration is being given to imparting skid resistance by sprays at the corrugators or printing presses.

MECHANICAL ROUGHENING OF FLAPS

The first attempt in obtaining nonskid properties in corrugated boxes in Union Bag-Camp Box Plants was through mechanical roughening of the outer liners on the flaps.

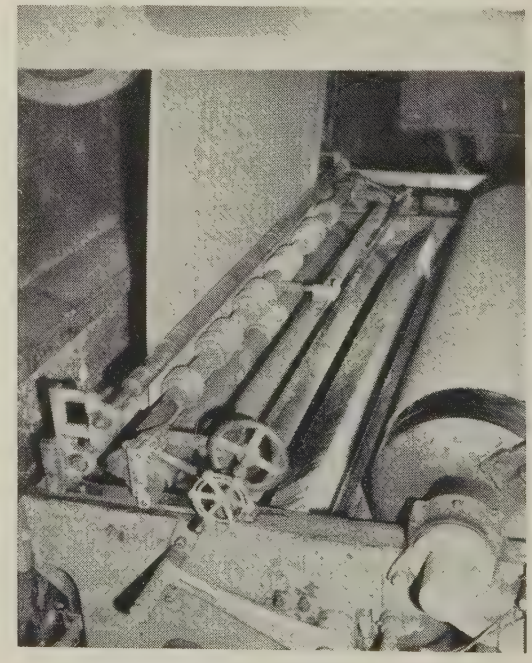

Fig. 1. Mechanical roughening of the outer liner at the doublebacker on the corrugator

Ned Varner, Superintendent, Box Technical Department, Union Bag-Camp Paper Corp., Savannah, Ga.

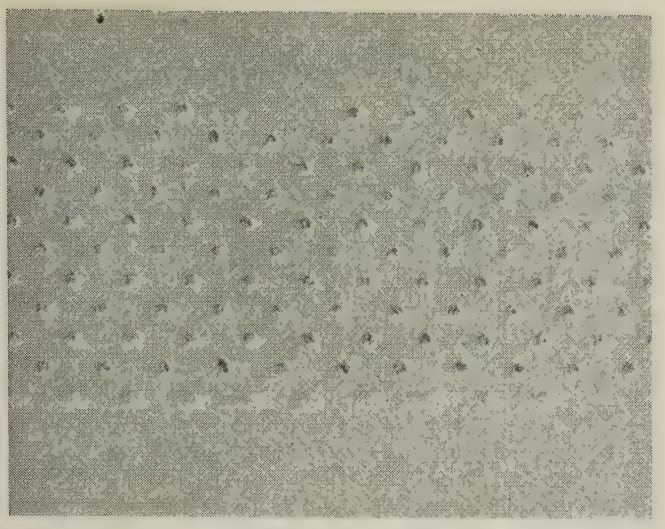

Fig. 2. Sample of "dimpled" liner

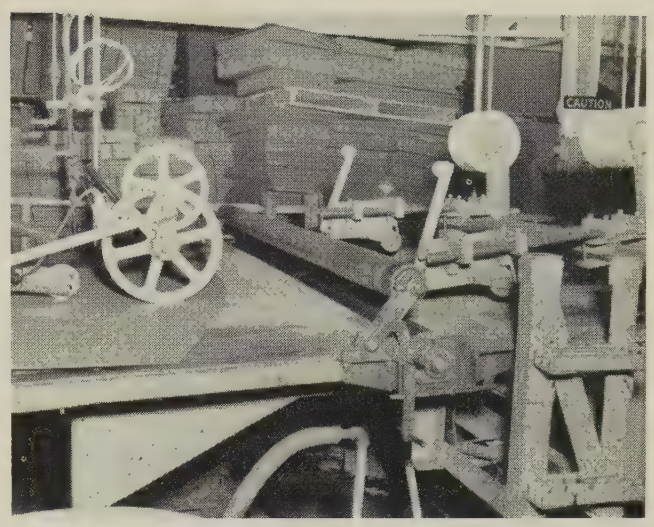

Fig. 3. Solid roll coater

This was accomplished by passing the outer liner between metal knurled and grooved rolls at the double backer so that the knurled roller indented or punctured the outer liner, as in Fig. 1. This process was variously knows as pointing, dimpling, or scarifying the outer liner. This first appeared to be a simple and inexpensive way to produce nonskid boxes, inasmuch as no extra operations or materials are required. However, it was found that in general the nonskid boxes made in this manner did not provide the skid resistance required in use and there were several disadvantages in this operation. It is understood that a number of plants have tried this method at one time or another, but that this has now been largely discontinued.

In combining the board with the perforated liners it was found that the indentations or perforations resulted in an unsatisfactory contact between the outer liner and the corrugations in the hotplate section, thereby requiring a heavier than normal application of adhesive. Also the raised points of the outer surface tend to keep the board away from effective contact with the hotplates, thus resulting in a loss of corrugator speed and an increase of waste. As a result in the increased adhesive application to obtain a satisfactory bond with the perforated liner and the decrease in speed to obtain effective heat transfer, an increase was also noted in warping of combined board when running perforated sheets.

In addition to the problems encountered in combining the perforated sheets, there are certain other disadvantages to increasing the skid resistance in this manner, including:

1. The mutilation of the flap surface makes printing of the flaps difficult and generally gives the box a poor appearance.
2. The perforations in the flaps have a serious effect on end load box compression with reductions of 10 to 15% being noted.
3. The over-all caliper of the board is increased significantly and this results in thicker bundles of boxes for the same box count, thus resulting in need for more storage area.
4. It is practically impossible to use suction type automatic case openers for boxes with perforated flaps.
5. Case sealing is adversely affected.

To determine the static skid resistance imparted by the performations, samples of the board were tested on an inclined plane. Although the average angle of slide for the perforated board was increased appreciably over plain board, the results obtained were quite erratic. If the samples were placed on the tester so that there was an interlocking of the perforations, a high skid resistance was generally noted; but if the samples were placed upon each other at random, as in normal stacking of containers, very wide variations were noted in the test results, and it appeared to some instances as though the raised portions, shown in Fig. 2, acted as bearings and the skid resistance was very poor.

ROLL COATINGS WITH COLLOIDAL SILICA SOLUTIONS

After considerable experience with mechanical roughening of the flaps on the corrugators, efforts were directed toward obtaining satisfactory nonskid characteristics by roll coating the outer liner with colloidal silica solutions. The initial production with these coatings was made with a solid roll coater which already existed on the corrugators for the purpose of adding moisture to the outer liner when running heavyweight linerboards. This roll coater extended across the web and was located between the dreir section and the slitter knives at the corrugator as shown in Fig. 3. The roll was partially submerged in the solution at the bottom and came in contact with the outer liner of the combined board at its upper periphery, thus transferring the solution to the liner, as indicated in Fig. 4. No attempt was made to doctor or meter the solution on the roll; and, surprisingly, there was very little difference in the amount of transfer at various corrugator speeds. This application was very satisfactory, but was not economical inasmuch as the solution was applied across the width of the web, including many areas in which it was not needed, particularly when orders requiring nonskid treatment were trimmed with other orders.

To eliminate the application of nonskid coatings in areas where they were not needed, a number of removable roll segments, as shown in Fig. 5, were made up so that they could be attached to the solid roll coater to apply the solution only at those areas where it was needed, which was generally on the flaps for combined board to be used in regular slotted boxes. This was very satisfactory and the only disadvantage was

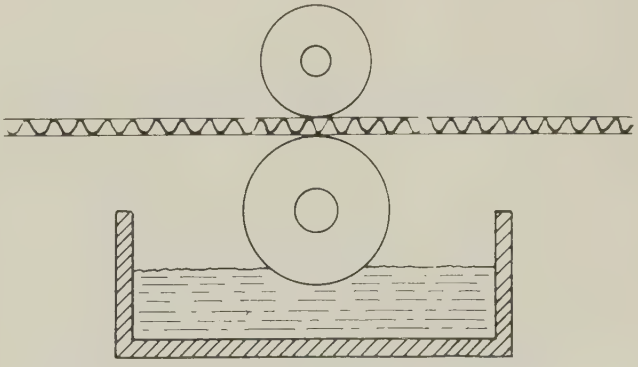

Fig. 4. Solid roll coater

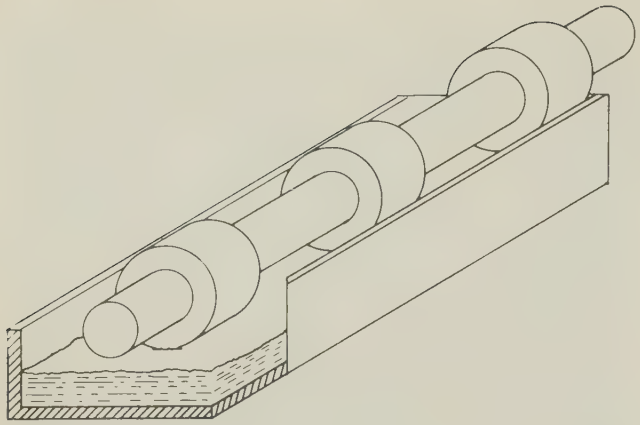

Fig. 5. Segmented roll applicator

that a considerable amount of setup time was required in changing orders, particularly from orders requiring nonskid treatment to orders of heavyweight board which require moisture application across the sheet. In this instance it was necessary to remove all of the roll segments.

The third method tried in applying colloidal silica solution was by running the solution in the pan below the level of the solid applicator roll and placing pieces of felts in the pan which were partially submerged in the nonskid solution. These felts are in contact with the applicator roll in the areas where the coating is required on the combined board. The felts are confined in brackets and can be readily shifted to the areas where the point of contact is needed. (Note side view in Fig. 6.) It was thought that by changing the pressure between the felt and the applicator roll that the amount of pickup and transfer could be controlled to a very fine degree, but experience indicated that variations in the pressure have very little effect upon the amount of application. This method is currently being used and is found very satisfactory. It reduces setup time considerably as compared to the segmented roller application.

There have been no serious production problems in applying colloidal silica solution by rolls at the corrugators. Considerable rusting occurs at the slitter knives, scores, and shafts at the triplex slitter when the solutions come in contact with these, but this is readily removed by wiping these parts with a solution of oil and a cleansing powder.

In roll coating of board with silica solution it was found that the best means of controlling the amount applied was through controlling the percentage of solids used, with concentrations normally varying from 5 to 10%. It was also found that the over-all nonskid effectiveness for board coated with silica was highly dependent upon the finish of the untreated stock. Experimentation carried out in Savannah depositing various amounts of colloidal silica on four experimental lots of paper with widely different finishes, ranging from very smooth to extra rough, indicated large differences

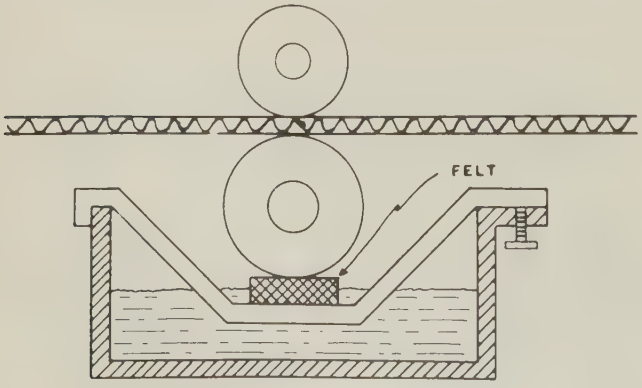

Fig. 6. Felt applicator

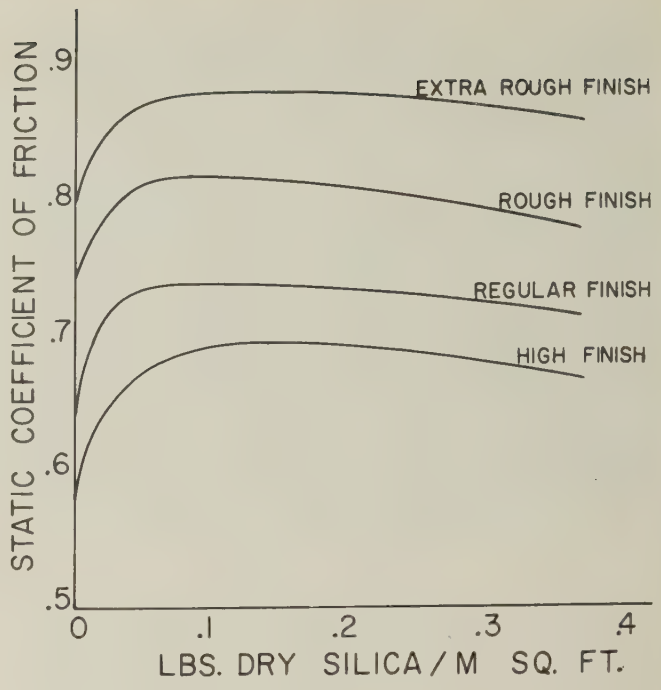

Fig. 7

in the static friction of the untreated papers as indicated in Fig. 7. A sharp increase was noted in static friction for small amounts of silica with a leveling and subsequent decrease as the amount deposited was increased further.

The behavior of kinetic friction was not consistent for the different finishes. For the rough and extra rough finishes the kinetic friction gradually increased as the amount of silica was increased, but for regular and high finishes the kinetic friction for small amounts of silica was less than for the uncoated stock. As the silica application was increased considerably, the friction values were greater as noted in Fig. 8. An explanation of this somewhat unusual behavior is not known at this time. All friction values reported were determined on a friction meter developed by The Institute of Paper Chemistry.

The application of silica solutions has no appreciable effect on the appearance of finished boxes, although upon careful

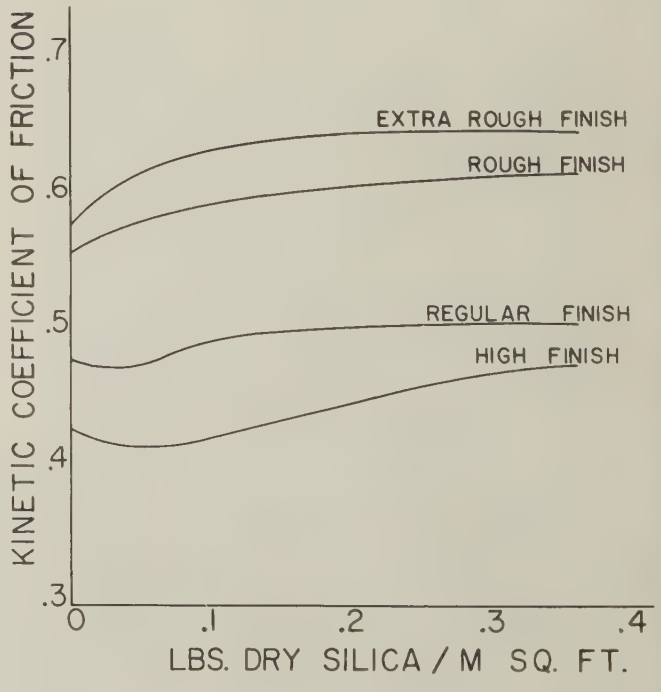

Fig. 8

examination the coated area is generally slightly darker than the untreated area. There are claims that the silica application reduces ink consumption and improves printing quality, but no large differences in printing between the coated and uncoated board have been obvious in the Union Bag-Camp box plants.

No attempts have been made to apply colloidal silica solution by a spray method at the corrugators in the Union Bag box plants, inasmuch as the spray would have to be applied from the bottom side of the sheet. It is understood, however, that certain sprays have been developed which perform very satisfactorily for this application at the corrugators. It is felt that the roller coating is probably cleaner and more economical than the spray inasmuch as there is practically no loss of the solution; however, a spray properly designed and shielded would probably also result in very little loss of material. In regard to effectiveness, it might be that the discontinuous tiny droplets fom a spray coating would be superior to the almost continuous coating obtained in the roll coater application.

There are still a large number of unanswered questions regarding nonskid coating, particularly in regard to the degree of nonskid resistance required by different box users. The colloidal silica solution has attained wide usage and is apparently satisfactory for many customers' needs, however, certain customers have requested higher nonskid properties than have been obtained in Union Bag-Camp box plants with the colloidal silica application, and investigations are being carried out using other materials which are claimed to impart higher skid resistance. In one instance a customer inquired as to whether the use of dunnage and bracing could be eliminated in rail cars through the use of nonskid boxes. It is doubtful that any nonskid treatment can take the place of proper bracing of rail cars.

NONSKID APPLIED BY BOX USER

Although many box makers are now applying nonskid coatings in the box plants, the optimum point of application probably is on the box user's sealing line at the point where the sealed boxes emerge from automatic case sealers. This offers many important advantages, including the following:

1. By treating the outer flaps only there is a savings of about 50% in coating material cost.
2. The coating is fresh when the boxes are filled, with no loss of effectiveness due to possible deterioration of the coating during storage of flat boxes.
3. Only those boxes requiring nonskid characteristics are coated and the customer has complete flexibility as to the use of nonskid in any one run of boxes, depending upon particular conditions.
4. Since the coating is applied at the end of the sealing line, the boxes move easily through the conveyor system with no drag due to coatings applied in the box plants and no loss in skid resistance due to rub off on conveyor systems in the customers' plants.

The need for skid resistant containers of many box users is by no means imaginary and with the continued improvements in box appearance and still faster methods of handling filled containers, there is little doubt that skid resistance will remain a problem for the box maker.

Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

Offset Spray Equipment

C. H. ROBSON

THE topic assigned to me was "Offset Spray Equipment." There are probably no more controversial subjects than the material, methods, and equipment used to eliminate offset. I had a list of over 20 manufacturers of equipment for offset elimination. To avoid having a horde of individuals descend upon me with an idea that I had neglected them or had not properly put forth the merits of a particular process, the discussion will be limited to our experiences at Lanzit Corrugated Box Co.

Offset is the transfer of ink from the printed side of one sheet to the under side of the sheet placed on top. This is a problem which had always been with the printing industry. The earlier printers hung each sheet on a line to dry much as the housewife would hang laundry. Then they found that the operation was improved when a rough sheet was placed between the printed sheets to prevent offset. This was called slip sheeting. Slip sheeting had certain disadvantages such as additional labor, and storing of slip sheets between jobs. Sand and talc were also used to separate the sheets and prevent offset.

Modern paper and printing demands will not be satisfied with these methods. While it is necessary to separate freshly printed sheets, the space can be infinitesimal, just enough to keep the sheets from touching until the ink dries. This space no matter how small, always allows for the movement of vapor and speeds drying.

Theree are two main methods for accomplishing the sheet separation: (1) application of dry powder, and (2) by a spray which solidifies to a dry particle before it touches the sheet.

Fine powders, many of which are made from starch, are applied by spraying or sifting. Some even have a method of applying a static charge to the powder which aids in its dispersion. Many of the dry powders are extremely fine grain as small as 0.0005 in. The liquid sprays are composed of various fast drying varnishes or dextrins. Formulation of these are too numerous to mention.

More recently wax compounds have been melted and sprayed in a fine mist which quickly cools to a fine wax particle and falls on the sheet to provide the desired separation.

We have used liquid sprays and dry powder for a number of years. However when we had large areas of ink coverage, we were unable to prevent offsetting. One of the reasons is that due to the irregularity of corrugating board, the particles had to be somewhat larger than normal to keep all parts of the sheet separated. When we attempted to use larger powdered particles the equipment became clogged. When we used a liquid spray the particles would not become *solid* before they struck the sheet. Our solution to the problem was to use strips of corrugated placed around the sheet by hand to provide the necessary separation. This made a very unstable load and required that loads be kept at a minimum height. This, plus the large amount of floor space required for the loads created quite a problem in the plant. Many times, in spite of our care, the sheets would sag and drop causing offset.

Over a year ago we purchased a hot wax spray for use in display work. This equipment sprayed a fine particle of polyethylene wax which settled on the sheet and provided enough of support so that we were able to stack to 5 ft. high loads even with very large areas of heavy coverage.

The wax is melted and then atomized by hot air. Fine particles of liquid are congealed before they hit the sheet. The wax-poly particles settle rather than float in the air thus eliminating problems of ventilation. Wax on the floor did not prove a safety hazard but seemed tacky and was easily scrapped up.

A large percentage of the wax particles fell off the sheet during handling at the next operation. A portion of the particles remaining tended to adhere to the equipment in succeeding operations. However, an occasional spray of silicone mold release or special detergent eliminated any problem.

We did not find that the loads were excessively slippery because of the wax. However when we used powder, the

C. H. ROBSON, Lanzet Corrugated Box Co., Chicago, Ill.

sheets seemed to be slipperier. We are using a wax which is balanced between a very hard wax and a soft wax. Hard wax will provide good separation but be extremely slippery. A real soft wax would collapse under heavy loads and would not give proper separation. Wax if left on the sheet will give a surface which could cause difficulties in a can box.

Where we have used this material properly it has not caused any problems in the finished container. In fact we have had more of a problem with board having a highly finished surface where no spray was used at all. One of the major problems of obtaining antiskid properties is in the liner itself. The higher the quality of printing that is required, the higher the finish necessary on the liner. However the mills can be of considerable assistance in minimizing the problem of skidding and maximizing the printing qualities. The hot wax equipment is now being made available with an additional set of spray to dispense antiskid material on the board at the same time the offset spray is applied.

The best way to solve a problem is to eliminate it. Many times we make our own offset problems by improper use of inks and improper application.

We do not mean to say that in the present state of the art, offset can be eliminated. However, it certainly can be reduced. We found that by working with the roller and ink suppliers as well as the operating personnel, we were able to lay the right ink properly without using an excess. This was tremendously helpful in reducing offset and minimizing the use of sprays.

There has been some concern about the practicality of overprinting after having used the wax spray on the first pass. There are problems: however it can be done. We avoid it whenever possible, but we do have a number of jobs where this procedure is followed. To do this the ink and paper combination must be carefully selected and the wax spray kept at a minimum. There has been the practice with some inks to incorporate wax in the ink to reduce offset. These inks have been overprinted, so you can see that the problem of printing on a surface that is a little waxy, is not insurmountable.

Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

Scheduling the Corrugator

O. M. CLINE

Over the past several years the corrugated industry has absorbed a steady flow of wage and material cost increases. To combat these increases and to continually improve its product, the industry has had to look for more effective ways and means of manufacture. Since the corrugator is the primary manufacturing operation in making corrugated board, it is felt that the greatest gains can be made by scheduling and operating this machine at its optimum production capacity.

To reach optimum capacity one can provide various mechanical and electrical devices to improve the corrugator operation. Also all plants should seek ways to produce more square feet of board per hour by utilizing the full width of their machine. This can only be accomplished by better and more comprehensive scheduling of the corrugator runs.

The primary requirement for scheduling, that allows the use of the maximum machine width, must be done on a machine equipped with a double cut-off knife. Secondly the actual scheduling of the orders to run should be done by someone completely familiar with the manufacturing operation and who has a good working knowledge of basic arithmetic.

Scheduling to obtain the maximum width must work on the basis that, the size roll stock available will control how the order is to be lined-up to run. The sheet size of a particular order should not control the width of roll stock to be used.

The first step of scheduling is to separate all orders by tests and by flute within that test. Secondly the orders of each group are sorted and placed in the sequence from the smallest to the largest width (corrugation way).

The scheduler then picks the orders that must be corrugated and from inspection of these orders as to their size, quantities, grade, and scoring, he decides which of the available roll widths he will use to run the orders. At this time each of the "must run orders" are taken individually and the number of lineal inches of paper needed for each order is determined. Dependent on the blank sheet size of the order the scheduler may figure the lineal inches for running it one, two, three, or four out. It is advisable whenever possible, to run no more than a combination of four out off the corrugator knife. It is a proved fact, that the more pieces out of a given width the corrugator take-off crew has to handle, the slower the speed of machine, in terms of lineal feet per hour.

For example: three men constituting the corrugator take-off crew, can take three blanks off the bottom knife and one blank off the top knife, with the corrugator operating at a higher speed than if they were to handle four blanks off the bottom knife and one blank off the top knife.

It is therefore advocated that only in extreme cases, where you may not have the "mix" of orders, so that you can trim the particular order concerned, should you resort to the practice of a total of five blanks out. Lineal inches are determined by the quantity of the order divided by the number out, multiplied by the number of cuts it takes to complete the order and the length of the blank.

For example: An order calling for 1000 blanks $21^1/_4$ by 48 in. might be run three out; thus becoming 334 cuts of the knife and 16,032 lineal in.

The scheduler is now ready to line up the "must run order" with other orders. He has decided that the roll stock size to be used is 85 in.

This size roll stock leaves the scheduler with the following alternate ways of trimming the "must run order." Taking the order of 1000 pieces $21^1/_4$ by 48 in. he will try to trim with other orders by:

1. Running the blank ($21^1/_4$ by 48 in.) one out thus needing 48,000 lineal in. of any order or orders that are approximately $62^3/_4$ in. in blank width or an order that can be run in multiples of two or three out equaling approximately $62\ ^3/_4$ in. in width.

2. Running the blank ($21^1/_4$ by 48 in.) two out thus needing 24,000 lineal in. of any order or orders that are approximately $41^1/_2$ in. in blank width or an order that can be run in multiples of two out equaling approximately $41^1/_2$ in. in width.

3. Running the blank ($21^1/_4$ by 48 in.) three out thus needing 16,032 lineal in. of any order or orders that are approximately $20^1/_4$ in. in blank width.

It should be stated that using the above procedure the scheduler is allowed to vary the number of pieces run of each order from 2 to 10% overrun. This overrun is normal to allow for secondary operation waste, plus the allowed trade custom of shipping slightly over face value of the order.

There must also be a limitation set on the amount of side trim to be taken at the corrugator slitter station. Normal limitations of total side trim are $^5/_8$ in. minimum to $1^1/_2$ in. maximum. If this maximum limitation is not maintained one can quicky lose the gain of square footage by the extra loss of trim waste.

It is felt that most corrugated plants can do a better job of scheduling by taking advantage of their full corrugator width. A factor that could limit to a degree this advantage is the "mix" of orders that any one plant runs.

"Mix" is a term meaning the average amount of square

O. M. Cline, Mead Containers, Inc., Chicago, Ill.

footage in each of the various grades, average number of pieces of each order, and the type of corrugated (box, inner-packing, die cut, etc.) to be run in a given period of two weeks. Within the "mix" one will often find certain orders that are impossible to trim to full advantage.

For example: 2500 cartons of 400-lb. double wall having a blank of 55 by 132 in. requiring 330,000 lineal in. For most plants it would be an impossible task to find other orders to run with this. It normally would be run from roll stock to fit this blank. Orders of colored liner usually must be trimmed from roll stock that fit the required blank. These types of exceptions we will normally have.

With the corrugated trend to bigger, stronger, and more display type board, we may be able to schedule in the near future full machine widths for what are now classified special runs. Another step toward more comprehensive scheduling would be to set up a predetermined schedule of the grades to be corrugated. To do this one would have to determine what the "mix" is by the per cent of the square footage of each grade, to the total square footage corrugated in a given period. This would then be set up into a predetermined schedule of running each particular grade one, two, three, or four times each week as the total percentage of that grade would normally require.

For example: The grade breakdown by percentage for a plant running both C and B flute could be as follows:

125 lb. and 175 lb. C flute..9%	125 lb. and 175 lb. B flute..4%
200 lb. C flute.55%	200 lb. B flute.10%
275 lb. and 350 lb. C flute..8%	275 lb. and 350 lb. B flute..3%
All Double Wall 11%	

Based on the above percentage figures, a schedule for predetermining the corrugator run of grades can be made. The allotment of machine running time must be given each grade in relatively the same proportion as its percentage of the total square footage.

The plant should try to schedule running all of its footage of a grade with a small percentage at one time. This would allow the advantage of accumulating orders of that grade for the run giving them more opportunity for trimming to their maximum corrugator width. Using the above, one can set up his weekly run schedule such as Monday run 125 lb. C flute, 175 lb. C flute, and 200 lb. C flute. Tuesday run double wall, 275 lb. C flute, and 200 lb. C flute. Wednesday run 200 lb. C flute, Thursday run double wall, 275 lb. and 350 lb. B flute, 275 lb. C flute and 200 lb. C flute. Friday run 125 lb. B flute, 175 lb. B flute, 200 lb. B flute and 200 lb. C flute.

This type schedule will work to the advantage of the company in several respects.

1. As stated previously, it allows accumulation of orders of a grade giving more opportunity for better machine trims getting more square feet per hour of operation.

2. It puts an end to grade jumping and size jumping allowing for more actual running time and less setup and change time.

3. It allows placing the roll stock at the corrugator in advance and setting of the corrugator heat and paste systems without continual changes.

4. It allows longer runs of a particular grade at one time, producing better bonded and flatter board.

5. It allows sales service and salesmen to make more definite promises on when an order will be run.

6. It allows less roll stock widths carried on the paper inventory.

The most difficult part of maintaining a predetermined schedule is getting the sales department to accept it. Once it is accepted it not only works to the plant's advantage, but to the advantage of the sales force from sales service to the salesman. Customer commitments can be made as the running schedule is determined. Thus, every inquiry does not have to be delayed by a phone call finding out when a particular grade will be run.

The better business is and the more orders one has to run the easier it is to maintain full width and predetermined scheduling. The advantage of more square feet per hour during peak periods should please both sales and management. A drop in business volume makes scheduling of this type more difficult, but must be worked at regardless of how adverse conditions become.

Scheduling the corrugator to over 90% of its width and on a predetermined schedule of grades is not just theory. It's being done at the Industrial Division of Mead Containers in Chicago. The average width trimmed on their 85 in. corrugator is $79^{3}/_{8}$ in. or 92% of width capacity.

Their side trim averages 1.3% or approximately $1^{1}/_{8}$ in. The roll stock used over the past two years has been 19% 77 in. wide, 24% 80 in. wide, 42% 85 in. wide and all other widths of roll stock 15%. Corrugated container plants must take a lesson from their big brother the papermaking industry which always maintains 95% of machine trim and runs on a predetermined schedule of grades. One must maintain effective scheduling to help keep from coming out on the short end of the economic spiral that has developed. The same materials at a higher cost will not run better and the same personnel at higher wages are not going to work harder. The container plants must plan and take the necessary steps to schedule, seeing that they get the most possible square feet produced per machine hour run and man hour worked.

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Materials Handling by Pul-Pac for Container Manufacturing

G. R. WILMER

First of all, we would like to point out that this entire system is predicated on the particular pattern of box business and physical appointments experienced at our Grand Rapids plant. We had to do considerable experimentation in developing this system. Our engineers had no experience with this method in any of our plants. However, the Pul-Pac operation was being used by the Kieckhefer Container organization which has had considerable experience in this field. Our Pul-Pac trucks are a standard item, being a product of Clark Equipment Co., Battle Creek, Mich., and are in general industrial use.

Adapting this standard item to specific box plant use involved considerable planning. Initial problems concerned the determination of time loads and work loads for individual areas in which specific trucks might operate. Perhaps the most important factor of all was the development and carrying out of a driver training program. There also had to be major adjustments of what might be regarded as "standard" storage areas in the plant which serve the various machinery units. Another phase, closely related to the driver training program, was the development of a communications practice, so that drivers and machine crews exchanged information necessary for proper movement of work as well as anticipating requirements at machine centers. Finally, the system had to be developed in the face of a number of qualifying conditions, ranging from aisle limitations to truck body height limitations.

EQUIPMENT FOR HANDLING

As a basis for understanding this system, a review of the equipment components becomes necessary; the Pul-Pacs do not operate in a vacuum but are coordinated with other items of equipment and machinery in the plant. First, there are the trucks. The plant has eight Pul-Pac units. Seven are in regular service and the eighth serves as a reserve unit

G. R. Wilmer, American Boxboard Co., Grand Rapids, Mich.

(although it actually carries a large workload itself). These are standard Clark trucks and have the Pul-Pac attachments. Five of these trucks are designed to handle a 4000-lb. load, 15 in. from the mast. One truck handles 4000-lb at 25 in. from the mast and one carries a 5000-lb. load at 16 in. from the mast. The latest unit will handle 5000 lb. at 24 in. from the mast. Each of the distance figures cited is subject to a 3-in. loss for the front end unit. Of the eight trucks at the plant six are of high-mast design being 124 in. high. Two are of low-mast design, being 72 in. high.

The reason for the use of the low mast trucks is to meet certain carrier limitations in truck trailer bodies and rail cars. With the high mast trucks it is possible to load to maximum height, within 10 to 12 in. of the plant ceiling, thus getting maximum space utilization. This focuses attention of the major reason for selection of the Pul-Pac method of handling: American Box Board chose it because we felt it represented the most economical method. A major factor in economy is that it permits maximum use of the cubic area of the plant for storage of work. It also pinpoints the cost of material handling. Another important phase of the equipment aspect of the Pul-Pac system is its coordination with other units of handling equipment, such as floor conveyors. Approximately 170 10-ft. long roller conveyors and a smaller quantity of other length conveyors are used in the plant. To permit flexibility these sections are not secured to the floor and are moved around as needed. The conveyors are used at all centers of equipment within our plant as well as in our local delivery trucks.

The major aisles in the plant are 12 ft. wide. This width was predicated on the normal maximum length of materials we handled with existing equipment plus the optimum operating space or radius required by the Pul-Pacs in their normal work sequences (such as passing, etc.).

GETTING TOP EFFICIENCY

These conveyor sections are very important to the successful operation of the system. They provide space for temporary backlogs, to compensate for the lack of coordination between truck drivers and machinery. As any plant manager knows, it is very difficult to synchronize these operations. Without conveyor sections on which to deposit backlogs, either the machinery would wait for the trucks or the truck drivers would wait for the work. Use of these conveyors enables machine crews and truck drivers to work at peak efficiency.

Another adjunct to efficient handling is the use of portable conveyors leading into railroad cars. Pul-Pac drivers deposit their loads on these, thus creating a backlog for the men working in the car. This is in addition to the conveyor practice in the solid fiber department of the plant. Here, the portable conveyors are higher from the floor than those used in handling corrugated work since solid fiber loads are heavier, hence more difficult for machine crew members to handle. A higher conveyor eases their lifting load.

TRANSFER OF SHEETS

At this point, a "play-by-play" description of the handling job may clarify the operating details—show how these trucks transfer sheets from job to job in the plant. Starting at the end of the corrugator, the stock handlers place their loads on scrap sheets, usually known as draw sheets. These are simply corrugated board. We have found through experience that corrugated board is better than solid fiber for this use—contrary to general belief. Each such sheet protrudes about 4 in. beyond the edge of the load to facilitate handling by Pul-Pac trucks. Most generally the corrugated draw sheets are placed with the flutes running at the same direction as the flutes of the load being handled. Sheets are positioned for both end-wise or side-wise handling whichever best suits the truck doing the job and the necessary way the subsequent operation demands, and stand on the portable conveyor until picked up. Next, a Pul-Pac driver moves his truck toward the load, actuates his loading mechanism and lifts the load into position for movement of the truck. Now, he backs out of the conveyor area and backs down the aisle to the storage area. He backs past the point where he is to deposit the load, then stops, and drives in (forward) to the point where he is to place the load. If he deposits the load at a slight angle, he then "pivots" it to correct position, in alignment with other loads. After positioning the load, the driver backs out, then drives forward (empty) to return to the corrugator, where he drives in, meets a load and repeats the process just described. He drives forward only when empty. A strict rule requires that all driving with loads be done in reverse; the driver cannot see over his load when looking ahead of his truck, also a sudden stop could quite likely result in an upturned truck.

ASSIGNMENT TO AREAS

Since the foregoing description suggests a certain inflexibility in truck movements, it is necessary to point out that the plant is divided into six areas. To each of these areas a Pul-Pac truck is assigned, but is not restricted. This provision is important to assure flexibility. While each truck operates primarily in its assigned area, it is not inflexibly confined to that area, and is frequently assigned to provide temporary handling movement elsewhere. Designation of areas raises the question: How did the plant determine the areas to which trucks are assigned? This was done on a basis of time study and related methods in accord with normal industrial engineering procedures. It took 2 weeks to complete this study. This phase is restudied periodically as new equipment is added, old equipment discarded or work mix changes occur. It is checked annually even if there haven't been significant changes. The relative work load for each area was established by a flow chart. An important objective was to plan the operation so that each truck would do its job with minimum mileage. The over-all plan was predicated on the physical layout of the plant. However, the engineers did not do this project independently. They worked closely with executive and supervisory personnel, including by all means the "foreman" of the areas being studied. In this way those who came to assume the responsibility for the working of the plan had a part in its development and were able to advise the engineers on specific details of practical operations. An important result was that the areas selected after the studies became subject to reasonable variations in order to provide the flexibility suggested in the preceding paragraph. In addition the same provision for flexibility applies to the conveyor sections in serving as backlogs to avoid: (1) tying up truck drivers at machine operations, and (2) making machine crews wait for stock. Thus, at each operating point there is provision for a backlog of three to four loads, so that the driver in effect keeps that many loads ahead of the machine crews.

ANALYZING THE JOB

We would like to emphasize that, basically, the success of the system depends on how well drivers are trained and, once trained, how well they carry out their assignments. Materials handling is treated as important work at the container plant as well as our other installations, and one who is assigned as a Pul-Pac driver is regarded as having a responsible job. The simplest way of focusing attention on the importance of this job is to list the other jobs in the container plant with which the driver's job is grouped. Among these are the following: slitter-slotter operator, assistant press operator, scoring machine operator, and corrugator knife-man. We have evaluated the rates for this job on a relatively high basis because we believe it is an important job and because we want to interest and keep capable men on the Pul-Pacs. As a result, drivers are selected and trained with care. Once assigned, they are effectively supervised so that American

Box Board gets the qualitative handling job it desires. All these truck jobs are on a semidirect incentive basis, and all operations have been analyzed and weighed. Numbers of loads and load capacities have been calculated. There are point values for all these operations. Drivers are paid, as a group, on a basis of work through the machine, and not merely on a basis of work delivered to machine areas. Use of an incentive system helps assure effective driver performance. If, for any reason, machines are running at less than capacity, it is customary to take drivers off this particular job rather than to reduce the work load of each. It is not unusual for drivers themselves to suggest that a given shift at a particular time operate with less manpower in order to assure adequate work loads for each, and if they do not, the group will be affected in reduced earnings. There is every evidence that this system (plus the training and supervision) results in the Pul-Pac operators doing a good job from the standpoint of work quantity as well as work quality.

TRAINING ALL-IMPORTANT

After deciding that the driver's job was an important one, the next step we felt necessary was to establish a training program calculated to produce drivers capable of meeting such responsibility. Aside from the job of getting the work handled, there are other reasons for having well-trained drivers. For example, these trucks are capable of doing much damage if mishandled. It is said a careless Pul-Pac driver could knock out a brick wall just as effectively as a power hammer could do the job. Basically, the starting point of the program is the selection process. Candidates for these jobs are selected from among those who have reasonable good records for being safety conscious in the plant. Similarly, we in management seek men who are known to be dependable and level-headed. Supervisors at all levels agree that getting a man with the right temperament is important because, in the final analysis, material handling work is at times nerve-racking and calls for a man of stability.

Supervisors have a series of talks with a man tentatively selected as a Pul-Pac driver. They require him to study the safety manuals of the equipment manufacturers, which stress safe practices for truck handling. They endeavor to emphasize not only safety and caution, but, also impress a prospective driver with the dollar value of the equipment and material he is handling. Not only line supervisors but also representatives from personnel and from maintenance confer with the driver candidate. After getting basic instruction, this man is assigned to the extra truck in the plant, and learns simple handling methods under a foreman's direct supervision. Next, he is assigned to the area of least activity at the moment, and works there—doing handling jobs under particularly close supervision. Until he proves himself a qualified driver he continues to receive this degree of supervision. As the driver candidate proceeds satisfactorily with his "extra" and initial assignments, he is assigned to a regular area—on the night shift. After this initial night period he then rotates between day and night work, just as do the other drivers.

COORDINATED SUPERVISION

At this plant the practice is for the area served to supply the supervision. Line foreman and other supervisory personnel direct the work of the truck drivers. However, since drivers frequently work in more than one area, special precautions have been taken to avoid the problem of different supervisors giving a man inconsistent direction. The general foreman is assigned as head of the materials handling committee of the plant. Other members of this committee include an industrial engineer, the shipping supervisor and another line foreman. The chairman of this committee coordinates the information and instruction given by others. In this way, all direction of handling operations is " of the same language" and assures a uniformity of direction and control. Fundamentally, the materials handling chairman provides functional supervision of the handling job. In other words, he supervises the job of handling—not the man himself. Likewise, line supervisors, who are directly supervising the individual, are giving the same kind of supervision to the job as specified by the materials handling chairman. We believe that the use of this committee and chairman has eliminated what otherwise would be an incorrect management practice, that of two supervisors instead of one to direct a man. However, the machine foremen and other supervisors working in the different areas closely control truck handling operations. Almost every day some foreman advises the drives on his shift concerning waste reduction and the avoidance of damage to loads and to stock. There is a consistent effort to reduce these losses to a minimum. Also, every supervisor in the plant has authority to take on-the-spot action regarding improper practices. Obviously, he uses judgment regarding his handling of a driver thus involved. Even so, if the situation is sufficiently serious (such as reckless driving) he takes whatever immediate action is necessary.

All drivers in the operation, Pul-Pac as well as fork truck operators have been schooled in what we consider to be the basic premises of safety. Meetings are held with the drivers group frequently to discuss unsafe practices that have been observed or to give instruction on newer concepts of safe operating. Listed below are the lift truck safety rules that each driver must observe. The list is by no means all inclusive but serves as a guide to certain fundamentals of safe operating.

LIFT TRUCK SAFETY RULES

1. The pantograph assembly is to be retracted at least a foot when traveling empty.
2. Operators of lift trucks must not allow riders at any time.
3. Persons not properly "checked out" or authorized will not drive lift trucks.
4. The normal way to drive lift trucks is in reverse. This allows better vision, lessens chances of up-ending due to quick stops; is safer in general. Drive forward only when absolutely necessary, or when empty.
5. When "moving loaded" the load on the lift should be close to the floor so that a sudden stop will not cause an up-ended truck.
6. When parked, at night, trucks should be parked with the forks down and on a sheet of corrugated board to catch any hydraulic fluid or lubricating oil which might leak from the truck.
7. Drivers are not allowed to leave their trucks with the motors running, except in a case where a load is being moved for fork pickup, etc.
8. Operators are responsible for cleaning their trucks and blowing dirt from them once daily.
9. Loads should be placed at least 18 in. down from the sprinklers.
10. Truck speed should be commensurate with safe driving practices as determined by visibility, area, etc.
11. Daily each lift truck driver is to fill out a "lift truck drivers inspection" form. This form serves the double purpose of preventive maintenance and keeping fork trucks in "safe" operating condition. The time should be noted on this form when the truck was blown off during the shift.
12. Horns are to be blown at all intersections as well as when backing out of "blind" storage spots.
13. Wherever 12 in. wide yellow lines appear across aisles it is required that lift trucks stop before advancing.
14. All liquid propane gas (LPG) cylinders in transit must be kept inside pantograph.
15. Empty cylinders are to be removed from the building as soon as possible.

16. Insure that the valves on empty cylinders are closed when removing the cylinder from the truck.

17. It is not permitted to lift more than one deck of material at any one time.

THE DRIVER'S JOB

These statements should not suggest that all of the burden for correct job performance rests with the driver. We would like to point out that the rest of the personnel in the plant have similar responsibilities. It is most important in such a handling program to make everyone aware that these trucks are operating. This is especially true for office and sales personnel who get into the plant from time to time, and who may not be so alert to the trucks as those regularly in the plant. While the drivers must follow all of the required safety practices, it is necessary for others to do likewise, such as to exercise care in walking—particularly at aisle intersections.

One of the important features of the job of the driver is to exchange information with drivers in other areas and with drivers on other shifts. Such information concerns primarily where to place certain work and similar operating details. This sort of informal communication greatly increases the efficiency of the handling operation. Of course, the load papers are there; it is a requirement that tickets and other identifying information be placed in a secure and visible place on each load. However, the good driver is the one who looks ahead, whose thinking is one order ahead of what he is doing. The drivers are alert to information given them by machine supervisors regarding what work is next for the machines. The result is that the drivers work from three to six loads ahead of the machines. All machine operations as well as hand operations, shipping, etc., have code numbers identifying them. The code numbers are listed on the factory work orders in the sequence in which the job is scheduled. The drivers are required to know each of these code designations because they constitute the major guide for flow of materials.

PUL-PAC MAINTENANCE

We at American Box Board feel that maintenance for the Pul-Pac trucks is generally like that of other trucks, except for the added requirements of the push-and-pull machinery and the special problems of Pul-Pac operations. Use of this kind of equipment is different from trucks generally; there are greater stresses and strains in different areas. For example, clutch life is a special problem, there is more "inching" back and forth. Even so, a good truck driver has less clutch trouble than a less skilled driver. The driver must not use the clutch as a brake; there is close supervision applied to overcome the natural tendency of some drivers to do so.

In general, however, our maintenance experience has been good. The company is getting good motor life. The experience with doing our own motor rebuilding has been excellent. Such a job, as we see it, means a complete, thorough rebuilding, and not a partial or stop-gap job.

The original Pul-Pac equipment as well as other types of power lift equipment was gasoline powered. Some two years ago we converted all our units to propane gas (LPG). The equipment ranges from Clarkats to Yardlift 60's. We used the "Zenith" type of conversion. We believe it of considerable importance after having talked briefly about maintenance and motor rebuilding, etc., to mention the advantages we feel conversion to LP has given us.

1. Oil changes, filter changes, spark plug replacements averaging four times as long as formerly experienced with gasoline.

2. Fuel expense, averaging 15 to 20% less at our rate of consumption per hour and at the price we pay.

3. We reduced our lift truck maintenance work force from three mechanics to two. (Based on 24 trucks (one half at container plant, one half at mill) all serviced in the container plant.)

4. Reduced fire hazard—no sparks from exhaust.

5. Over-all cleanliness in operation. Savings on cleaning light fixtures, etc., better personnel relations.

6. Engine life and efficiency greatly increased.

7. Thirty five to seventy per cent less carbon monoxide fumes (depending on condition of individual vehicle) according to State of Michigan, Industrial Health Bureau.

Disadvantages:

1. Initial cost of installation, $175.00 per unit plus three extra tanks at $26.00 each.

2. Must have assured and dependable fuel supply.

3. System must be regulated to operate on vacuum of engine or mixture will be too rich causing odor which people will question. This problem no longer exists in our plant.

MAINTENANCE BY DRIVER

The driver of each Pul-Pac truck has a definite responsibility for maintenance work. He makes out a report at the start of each shift which involves a check list of maintenance items. This report compels him to make a thorough, systematic inspection of his equipment. It includes a check of such items as oil, water in radiator, horn, Pul-Pac assembly, fire extinguisher, lift system, brakes, clutch, forks, dust blown out of radiator, gas, and other items. Each 8-hr. shift the driver uses an air hose to blow out the radiator and breather pipe to remove scrap fragments, dust, and the like. Also, as an incident of driver maintenance, drivers are required to watch for oil spots on the floor. Because of the hydraulic mechanism of the truck, these spots are found regularly. Each driver has a box of Speedy-Dry compound from which he makes an application to the oil spot. Another feature of the truck maintenance program is the use of the hour meters. These work off the ignition system of the truck and record the hours of operation. Maintenance work is scheduled on a basis of the hours of operation, as well as on a basis of visual inspection.

RESULTS WITH PUL-PAC

We feel that successful operation of the system depends on strict supervision so that all of the elements of the program (as outlined previously) are followed up closely. A distinct result of the system is better utilization of cubic space in the plant. This system makes it possible to use at least 40% more cubic space than would be possible with any other handling system that could be used in our plant. Clearance floor to ceiling is 18 ft. and loads are stored to heights as close to the ceiling as possible. However, attaining this success of operation and space use has not been so easy as these comments may suggest. Many problems had to be solved as the system crystallized into its present status. Some problems remain unsolved. For example, there is the question of whether or not to use traffic controls and stop signs at aisle intersections within the plant. We are currently making a careful study of all aspects of this question as a basis for reaching a decision in the near future.

Another result of the system is the advantage it provides us with clearly identifying cost of materials handling. This method eliminates distorting machine operations cost through having materials handling costs apart of them. Everyone can see the advantages derived as costs are calculated, individual jobs costs, budgets prepared, etc.

Most specific problems have been solved. For example, the plant produces many large boxes, such as mattress boxes. There are sheets to handle that range up to 180 in. long. To hold sag to a minimum and to solve the problem of handling these extra large sheets, we employ two pallets, side by side. A common problem in the early days of this system was the frequency of damaged loads. Now, even though spills and

other sources of damage are largely under control, the management maintains a continuous effort to reduce waste and damage through driver education and supervision. We employ several types of materials handling in the plant, but all or nearly all center, of course, around the pure Pul-Pac system and/or use the vehicle to accomplish the end result. For example, there are certain items such as small pads or partitions where spills were troublesome. To minimize the problem we use pallets to deck the small items on and subsequently pick up the pallet by Pul-Pac. Another example of the use of pallets or skids is applied when customers request we ship their products in this manner. But in all cases the Pul-Pac will handle the load.

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Printer-Slotter Washup Device

MYRON BLOCK

THE author would like to predict that should a printer-slotter be rocketed into outer space in the next 10 years it will be equipped with a Baldwin press roller washer. William Gegenheimer Co. Inc. has applied for a patent on such a device.

This prediction is based on the simplest of mathematics. Our standards department allows 0.45 man-hr. for a one-color ink change done manually on a 105-in. press. With a press roller washer properly installed and working properly this allowance is 0.26 man-hr., a reduction of 0.19 man-hr. On a two-color ink change this reduction would amount to 0.38 man-hr.

Several years ago Stone Container was concerned with the staggering nonproductive time in the normal operations of printer-slotters, and Charles Cumby, superintendent of Chicago plant, decided something could be done to cut down the time spent in making color changes. Consequently, the William Gegenheimer Co. Inc., which makes roller scrubbers for printing presses in other fields, were called.

Specifications were that the ink fountain and ink fountain roller would be cleaned manually and the scrubbing of the rollers was to be accomplished automatically in 5 min. or less, using no more than 1 qt. of solvent.

About two years ago, a washer was installed on a 122-in. press. The device has a nylon blade which is brought into contact with the upper steel vibrator roller along its entire length by a few turns of the operating handwheel. Running the printer-slotter at a moderate speed while solvent is poured over the rollers results in scraping all ink from the entire train of rollers. The ink is deposited in a removable ink pan.

The results were so encouraging that it was decided to equip all nine presses at our Chicago plant with roller washers on all sets of rollers. This battery of presses consists of Hopper, Langsten, and Universal presses. There are eight two-color and one four-color making a total of 20 sets of rollers. After two years we have 14 of these installations.

Fitting roller washers on existing presses is no mean job. Finding the space is the real problem. As not only the angle the blade impinges on the upper vibrator roller, but the location where to it impinges is critical. It was also found that on presses over 110 in. it was necessary to make the nylon blade in two pieces. This created a drainage problem on the blades at the center of the printer-slotter.

There is nothing to wear out but the nylon wiper blade. We do not know yet how long a life can be expected. The blade does not seem to wear evenly but 'only time will give an answer as to whether this will prove to be a great moment.

The removable pan is easily lifted from its brackets for removing the ink residue. In our operations we have found that a cleaning once a week is sufficient.

The nylon blade is mounted on a holder, which can rapidly be removed by removing readily accessible bolts. The blade and blade holder over which the dissolved ink drains must be removed and cleaned every 30 to 60 days. All in all about one-half man-hour per week is all that is required in the way of care and maintenance.

The only adjustment required is that to take care of wear on the nylon wiper blade. This is accomplished by turning a readily accessible screw a fractional turn.

The solvent must be applied to the rollers while the press is running. We have found that a 1-qt. squirt can is the safe way to apply the solvent. The solvent plays a very important role as it must rapidly dissolve the ink on the rolls. The dissolved ink must transfer from roller to roller to the upper steel vibrator roller. Then it must evaporate quickly when used as a rinse and in the removable ink pan leaving the ink residue.

The correct solvent is a real problem for us. We have a stock of about 150 different inks of both oil and diene base. We try to keep either oil or diene inks on a given press, but needless for me to say in this industry, we don't always succeed. So on all of our presses we are faced with scrubbing a wide variety of inks from rollers.

Some of our oil inks respond to paraffin oil and some to an alcohol-base solvent. The diene inks respond to various mixtures of glycol and the alcohol-base solvents just mentioned. We leave the selection of the correct solvent up to the press operator as one of the skills of his job.

The reaction of the press crews to the roller washers is the same as to any labor-saving tool. They viewed it at first with a little skepticism and reservation. This device must work to eliminate rags and scrubbing 100% to be accepted. There cannot even be any drippings to clean up when the roller washer is properly installed. Crews can be readily taught to use the proper solvent to get a completely automatic wash-up. This device in total is only a tool and if viewed in that manner, crews will accept and use it to attain the savings in man-hours for which it is intended.

Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

MYRON BLOCK, Stone Container Corp., Chicago, Ill.

Rotating Die Cutting Equipment

D. B. PHILLIPS

WE HAVE approached the operation of rotary die cutting from the angle of use for volume items. All our remarks concerning descriptions of machine and tooling should be viewed in this light rather than from the standpoint of use on short runs. Our development of each type of cut has come after the need has become apparent in our operation. We have concentrated our efforts on the Martin cutting attachment which is permanently positioned behind the printer slotter and chain driven off the lower slotter shaft of the press. We originally installed one of these attachments to cut the tapered flaps on lettuce as we had enough of that business in the Northern California area to make its installation practical. Naturally the first thing we did was not to taper lettuce flaps but to do something else. Our greatest need at this particular time was to reduce the cost of flap cutting a great volume of AFM citrus cases. From flap cutting, we progressed to curved and vent slots, rounded end hand holes, round ventilation holes and to the point where we rotary cut a baby food case that was formerly die cut.

Before proceeding with the details of tooling and operating techniques, we would like to briefly describe the cutting

D. B. PHILLIPS, Longview Fibre Co., Longview, Wash.

attachment. Rotary die cutting is a rather loose term when applied to certain operations in process of making corrugated boxes. It is not new in detail of application but is simply a combination of known methods newly applied. To best understand what has been done in this field, there are several points of view to consider.

1. Why do we want to rotary die cut various cases that have been made by the usual die cutter method or corner cutter?

This is very easily answered by the statement that we want to produce such items, where volume permits, at lower costs. The lower costs come mostly from the elimination of a separate operation. However, there are collateral benefits such as reduced storage area, shorter processing time, and meeting of delivery dates without overtime.

2. What kind of major equipment is required and at what cost? Some of the newer presses have accurate built-in slotter shafts that permit some die cutting as well as the normal slotting operation. We have not had any experience with this type of press but rather have been concerned with the necessity of providing one to one shafts for older presses. This was best accomplished by positioning such an attachment permanently between the press and stacker with a hinged pull roll transfer section to carry the blanks from the slotter shafts to and through the one to one cutting shafts. This allows for removal of the rather large amounts of trim at times, and still gives access to the press slotter shafts by means of the hinged transfer section. The unit itself is simply a set of heavy chrome-plated shafts with very accurately cut back-lash gears. The shafts are mounted in heavy bearings which are preloaded. The shafts are permanently spaced and have no means of adjustment such as score and slotter shafts have. We feel that this is very important, in fact, we feel that it is absolutely necessary and again we wish to remind you that we use these machines on volume items. We have used the shear cut principle in all our applications and to maintain the exact engagement of cutting edges for millions of revolutions, the shafts must remain on exact parallelism and on exact centers. Upon installation of these attachments, we make sure that the shafts are exactly parallel with no twists. We have found that even a slight twist in the shafts will result in misalignment of cutting edges when tooling is moved from one position on the shaft to another. The attachment is driven off the lower slotter shaft of the press and both driving and driven sprockets are ground to correct for any run out of sprocket teeth. Both sprockets are hardened. The pull roll transfer section is chain and gear driven off the main shaft with all sprockets and gears hardened with take up sprockets on all chains. These attachments add very little to the horsepower requirements of the press.

3. What kind of dies are used and what is their cost? As mentioned earlier, we have gone entirely on the shear cut principle. We would like to describe in detail the evolution of our flap cutting operation. In our description of the cutting attachment we took you through the point on the machine where we had a set of heavy chrome plated bare shafts. All tooling is built up using what we can best describe as standard increments. On the slotter shaft are placed heads with two vertical T slots. These heads have ground bores with a 0.004 in. sliding fit. The T slots are very accurately machined to be at exactly right angles to the axis of the shaft. Onto the heads are bolted bridges with circular keys machined into them, which fit in the vertical T slots. Next onto the bridge we place the tooling itself. Whatever the tooling is, it must be placed in a seat on the bridge that is at exact right angles to the key on the bottom of the bridge. This then puts the cutting edge exactly parallel to the shafts. In designing the flap cut heads and holders, we followed the proved principles of the corrugator cutoff. The blades have a high side and a low side with the high side engaging first in cutting across the length to the low side. This gives the same action as a pair of hand scissors and requires very little power and almost no pressure. However, great strength of shafts, heads, and frames is needed as well as the aforementioned extreme accuracies in heads and bridges to maintain this nice close shear alignment. An involute clearance is ground in the special hard steel blades and the leading blade is shimmed up $^1/_{32}$ of an inch to give it greater peripheral speed for clearance purposes. Several million cuts can be made on a set of blades, barring accidents. This begins to show the real necessity for careful machine work on tooling components and accurately cut back-lash gears.

Angle cutting of corners, such as on lettuce, calls for a different type of knife. When a straight line goes around the cylinder at an angle, a helix is formed. To get the shear action, the cutting edges must be at right angles of the axis of the rolls at the point of contact. This is exactly the same as the timing gears in a gas engine. When correctly made of hard steel and adjusted, many millions of boxes can be made without correction or replacement of blades.

Once the principle of fixed centers on shafts and accurate machining of heads, bridges and tooling is observed, almost any type of cut out tooling can be used. We have been successful in cutting as many as twenty holes in a citrus case at the same time as flap cutting. This operation did not come so easy as the flap cut development and we worked long and hard on design and redesign of the tooling with George M. Martin, our machinery maker. After several months of trial and error, redesign and further trial it became evident that to make cut outs in box blanks at satisfactory press speed with little or no down time, three separate and distinct functions must be performed: (1) the hole must be cut by the male and female die, (2) the cut out must be stripped out of the blank, and (3) the cut out must be ejected from the female die. All three functions are dependent upon each other and all must be performed satisfactorily to insure success of the rotary cutting operation. Blanks delivered to the joining department must be free of cut outs so as to eliminate the need for expensive hand stripping. The final design of the female die has worked very satisfactorily. The cutting surface is ground to the circumference of its travel. The bore is solid to a point about $^1/_8$ of an inch below the lowest cutting edge at which point there are several saw tooth ratchet rings. Below this the channel is enlarged to $^1/_8$ in. greater than the size of cut outs. A simple test revealed that it took 3 or 4 oz. to push a $1^3/_8$ circular cut out through a smooth die. It takes $1^1/_2$ lb. to push them through the saw tooth rings, but it takes about 4 lb. to try to pull it back out. This then gives a broader range for quality of cut, as the female will then have such a grip on the cut out that it will break or tear an occasional group of uncut fibers. The cut outs fall freely and mostly individually once they hit the relieved channel and blockages are almost nonexistent. The addition of appropriate jets of air between the bridge and shaft will practically eliminate any trouble with ejection. The male punch is a hollowed-out double-ended punch with a threaded hole in the center. A jacking screw is used in this threaded hole to make engagement adjustments. The punch is about ten points softer than the female die and is malleable. The cutting edges are blunt but narrow and can be peened. Thus for adjustment we jack the punch out slightly, then lightly peen the spot that is not cutting cleanly. This has worked out very well and is now under patent application. Also, the over-all pressure on the board has been greatly reduced by putting pressure only on the edges of the circle. This helps to get a clean cut as the earlier solid punches depressed the whole area and some tearing before cutting occurred.

For our particular use we have the holes made in sets of two and three, with permanently fixed lateral stops so that we can quickly go from citrus tops to citrus bottoms. This particular adjustment for a total of 14 holes plus the flap cut blade would only take 15 or 20 min. Needless to say the

original setup, wherein all the holders, bridges, and dies were placed on the shafts and alignment made, took a couple of days. The development of rounded end vent slots and rounded end hand holes followed the above principle with one notable exception. The male cutting segments on both have replaceable plates. Again, barring accidents, the plates have a cutting life of a million impressions or more. At a cost of from $7 to $20 each, this makes them no more costly than the replacement of ordinary slotter blades.

I have here a sample of a Gerber baby food case which was run two up on a Martin attachment. We simply combined the flap cutting, the angle cutting with the vertical slots put in on the slotter shafts to get this rather complicated product. We also have here samples of the citrus case with the ventilation holes on the top and bottom and on each side.

I am sure that you are interested in some cost figures on the machine and tooling. An attachment for a 42 by 94 Langston or a 50 by 88½ Hooper will cost between $10,000 and $12,000. Tooling costs will run about as follows: for each flap cut—about $600 for holders and blades. Blades cost from $17 to $50 each; replacements depending upon where you get them. Hand holes and vent slots cost about the same; namely, $600 for each hole. Cost for round ventilation holes is somewhat obscure as a lot of developments in cost are included. However, these will run in the neighborhood of $200 to $400 per hole. Again we would like to say that we have approached the problem from the volume basis angle as the initial tooling cost was not of major importance since we expected to pro-rate it over millions of cases. Our main concern was in foolproof design so as to reduce to the bare minimum the technical skill needed on the presses to set up the various parts. We feel that the machine shop is the place to make the permanent adjustment and in fact, all tooling made by our supplier, George M. Martin Company, are pre-registered and prealigned on miniature proof machines in their shop. Therefore, when we place tooling on our attachments, we expect them to cut and engage properly and cut without hours of relatively unskilled adjustment by press operators. This, plus the great care with which the basic machines are built, enables us to get long life and relatively trouble free production through the presses. We have not had long runs of the ventilation holes in citrus cases as this feature is still somewhat in the experimental stage in that particular industry; however, we have set up the hole punches, probably 15 or 20 times in the past year, and never have we had more than one hole that needed a slight adjustment to get into regular production runs. Most of our wear on this tooling therefore has come about from repeated setups rather than wear from operation. We expect to get 500,000 impressions on each end of the punch and 1 million impressions on the female dies before resharpening is necessary. Resharpening of a complete set will run in the neighborhood of $50 to $75. Replacement of a complete set of male and female dies will run in the neighborhood of $300 to $400.

I will also answer the $64 question which I know is running around in many of your minds and that is—what production rates do we get? We are now in our third year of cutting citrus either with flap cut only, flap cut with rounded end vent slots or flap cut with ventilation holes. On citrus tops which are printed four panels two colors, we average right at 5000 per hr. with a die set up about every 3 hr. On bottoms which are plain, we average between 5000 and 6000 per hr. with runs of 9000 per hr. not unusual. The production rates are for the month and include all set ups and changes back and forth between tops and bottoms. The presses so engaged are usually on this case alone and run 16 to 24 hr. per day. This, as you can recognize, is a tremendous advantage in that the press crews become very well trained on this one item.

As a footnote I might add that the press must be set up much more carefully, particularly in feed roll and pull roll adjustment through the press. Heretofore, all of us were no longer concerned with the register of the blank once it passed out of the slotter shafts or score shafts on the delivery end of the press. Now we are vitally interested in maintaining register out of the slotter shafts through the pull roll transfer section and into the main shafts of the cutting attachment. This provided many headaches for us until we got our press crews trained and picked up many operating techniques. You may well raise the question of accuracy of cut at this stage and I would like to say that the normal flap cut variance we work to is a sixteenth plus or minus. Yes, we get into trouble at times when the corrugator does not provide good flat hard stock. This is of prime importance as well as extreme accuracy of flap scoring on the triplex slitter at the corrugator. This one prime necessity of flat stock from the corrugator was worked on very, very diligently and with great success. Needless to say, you can recognize the advantage of that on all other types of business in the plant other than citrus, as well as all other operations in the plant, other than press operations. We have also done special scoring and perforating operations on the attachment. We believe that this field of operating has only been touched, and that many new items and methods will be developed. Many other plants have used these attachments, and I am sure have developed tooling and techniques that are just as interesting.

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Rubber Scores

J. D. HILL

We have been using rubber scores at Lawrence for about three years. I can remember the first day they were installed very well. We had a 5000 order of big nontest boxes and the inside liner was entirely too dry and brittle. You have probably all had occasional orders where it seems as if the first touch of the score cut clear through the liner and you either had a slit liner or a score that broke all over the map. The printer-slotter crew had been working with the scores for a half an hour, had tried water sprays, sponging, and I don't know what else and were about ready to throw the boxes out. At that moment, the superintendent walked up and said, "Say, those new rubber scores have just been delivered at my office. Why don't you get them and try them on this order?" A few hours later when the scores were installed, the boxes were run, the order was shipped and accepted by a very critical customer and the machine has never been without rubber scores from that day to this.

We run a lot of board with heavy corrugated medium. Some of our Freezurboard has a flat crush over 80 lb. per in. on A-flute. Where this condition prevails, the rubber scores are especially valuable. On standard 200-test board with good liners, I doubt if rubber scores much more than pay the maintenance costs. But, on poor liner or high flat crush corrugated mediums, they are very valuable.

The savings of certain orders is only part of the story. Like many of you, we send boxes once a week to be tested by Container Testing Laboratories. After the scores were installed, I gave orders that for the next month the boxes that were sent in to be tested should come off that machine. On box crush, our end-to-end compression has been running about 95% of standard and varying from somewhere around 92 to 97%. Once the rubber scores were installed, the end-to-end average jumped to 105% with little less variation. We could not notice too much change in the top-to-bottom crush. There may have geen some, but the change was not enough to be noticeable over the usual variations.

We have found that we get more efficiency from our stitchers and tapers than we did with metal scores. The score breaks true oftener and you don't see operators pulling and

J. D. Hill, The Lawrence Paper Co., Lawrence, Kan.

beating boxes to straighten the score nearly as often as we did when metal scores were used.

Today all of our printer-slotters are equipped with rubber scores, but we have learned considerably about them since the first time. For instance, the diameter of the score must not be changed. The durometer of the rubber is important and we have used all the way from 50 durometer to 70 and are now using 70 durometer rubber. We grind an old score down $^3/_8$ of an inch and then place a $^1/_2$ in. slot in the score. This slot is $^1/_4$ of an inch deep and the rubber is placed in these slotted scores by the same people who make the rubber rolls for your printer-slotters. It is important from a wearing standpoint that the rubber be well anchored to the steel. The surface of the rubber should be about $^3/_8$ of an inch above the steel score or $^5/_8$ of an inch above the bottom of the slot. Our scores last about 9 months to a year with better than 16 hr. a day of operation. In that time, we save more than enough orders to pay for the scores and the installation so that the extra quality is just gravy.

The rubber on this $^1/_2$ score in my hand was vulcanized on the metal by Samuel Bingham and Son Manufacturing Co. in Chicago. An old wornout metal score can be found to receive the rubber for about $3.00. It costs $11.23 to get the rubber installed. New scores made this way cost us $48.15.

The male score is the standard Langston V furnished on any Langston printer-slotter. As far as we are concerned, the right durometer rubber will mold itself under pressure into a much better female than anything we can design out of steel. Furthermore, this female has the advantage in that it can mold itself to suit different caliper liners so that we are running liners from 9 to 26 points with what we consider a minimum of difficulty. Also, a small error in setting the female does not cut your liner like a contoured metal female score.

I am holding in my hand where you can all see it here a section of one of these scores so that you can see how the rubber has been molded down into the score to give the female a firm base, yet gives plenty of room above the steel to allow resiliency in meeting the pressure of the male score. When I agreed to make this speech I thought we would have had experience on using permaflex instead of rubber. This is the material many of you use on your stitcher pull rolls. Unfortunately, these were held up and we will not get them installed until sometime next month. We think they will last much longer than rubber.

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Organization and Operation of Maintenance Department, Including Rebuilding of Equipment

NORMAN ALBIN

THE purpose of this presentation will be to present the importance and means of establishing a maintenance department.

Maintenance itself is concerned with the daily problems of keeping the physical plant in good condition. An engineering group is necessary to instruct this department in the additional area of alterations and additions to the plant or equipment. Our industry usually combines both groups under the heading of maintenance.

The ideas I am going to offer can be used in either a sheet plant or multiple unit corrugating operation. To paraphrase Einstein, "It's all relative." You can make your own adjustments for newly organized companies or smoothly running well established firms.

My suggestions were gathered through visits to many plants, from discussions with leaders in our industry, and from our operation as a converter. We, at Triangle, started like many others by buying and overhauling used equipment. We did so much of this that we found ourselves with a well equipped machine shop, a group of skilled mechanics, and operating a used machinery sales company.

Those who gave me their ideas caution you to do as they say, and not as they do. They were "kidding" of course because, even though there is a big gap between realization and achievement, the awareness of a job to be done is the first step.

MAINTENANCE

Profits result from more sales, higher profit margins, or lower costs. The market place fixes the first two but management has control of the last. Maintenance is a controllable expense and depends on management's recognition and financial backing. I am sure that after I finish the sales department won't be fired, but I hope to get maintenance the recognition, cooperation, and financial backing it deserves.

As our industry does not own or control our customers, we are constantly fighting the raids of many competitive industries, such as wooden boxes, drums, bags, glass, plastic, and many others. They can hurt as those who used to make mattress boxes can attest.

Maintenance can help us grow by devising new and low cost methods of production. Maintenance does it part in our regular annual increase of tonnage.

Preventive maintenance is the type with which we are most familiar. Preventive maintenance can effect the greatest possible savings in over-all manufacturing cost. Down time not only adds to the production cost per thousand square feet but the total sum may be greater in terms of affect on schedules, with resultant customer dissatisfaction and cancelled orders.

Preventive maintenance should not only cover production machinery, but should include building, material handling equipment, motors, controls, lighting, plant services, and other process equipment.

Maintenance no longer covers oiling, greasing, and making emergency repairs. Today's personnel must be experts in electronics, electricity, pneumatics, mechanics, and now hydraulics.

Maintenance covers the following daily tasks: preventive work, design, repairs, safety, plumbing, roofing, painting, mechanical, carpentry, electrical, ventilation, materials handling equipment, elevators, and many others.

They must be experts in using brick, electrical equipment, glass, heating equipment, high pressure equipment, lumber, paint, roofing, sanitary fixtures, ferrous products, valves, abrasives, bearings, drives, lubricants, motors, hand and precision tools, and nonferrous metals.

The materials used by maintenance men are costly, and according to Factory Management and Maintenance Index have gone up from a price index of 100 in 1947, to 167.9 in October, 1957, and will probably continue its monotonous rise.

MAINTENANCE DEPARTMENT

The first reason a factory needs a maintenance department is to insure availability of machines and buildings.

The second reason is one of necessity, know-how, precedent, or because there is no other logical department to which many responsibilities can be assigned.

Dependence on this group has grown with the complexity of facilities used in a modern corrugated box factory.

NORMAN ALBIN, President, Triangle Container Corp., and Norman Albin and Associates, Chicago, Ill.

Maintenance exists today as a necessary facet of the whole plant's operation.

Maintenance primary responsibilities are:

1. Maintenance of existing plant equipment.
2. Maintenance of existing plant building and ground.
3. Inspection and lubrication of equipment.
4. Generation and distribution of utilities.
5. Alterations to existing equipment and buildings.
6. Installation of new equipment and buildings.

Secondary duties consist of:

1. Storekeeping.
2. Plant and fire protection.
3. Waste disposal.
4. Salvage.
5. Insurance administration.
6. Janitorial service.
7. Property accounting.
8. Pollution, noise abatement, and elimination of excessive heat and moisture.
9. Plus any other service delegated by management, such as repairing the bosses' household items.

PERSONNEL

We are lucky as machine tools and men can duplicate themselves. The most satisfactory and easiest method is to hire men with previous crafts experience, particularly in small companies who can't justify and afford costly formal training programs. The next method is on-the-job coaching. This is accomplished by having an apprentice understudy an experienced craftsman. This is supplemented by exposure to different men and areas. The third method is a training program of your own.

Delegate responsibility to carry out the program. Set up a method of recruiting trainees from production crews, newspaper ads, and other sources. Give potential trainees preliminary aptitude tests, such as Kuder Preference and Bennett Mechanical Comprehension tests. Training programs cost money and you might as well start out with no strikes against you.

Get your Union's cooperation. Most of our maintenance shops are in over-all company unions. I consider this far more favorable than being tied up with many separate craft unions. Unions most commonly recognize the system furnished by the Bureau of Apprenticeship, U. S. Department of Labor.

Determine how, when and where training is to be given.

Set standards of performance.

Create job progression schedules for job classification and wages.

Set the courses and hours of training in each area and budget the costs.

You can use any or all of the following methods of training:

Actual shop practice.

Instruction by manufacturing department supervisors.

Instruction by engineering department personnel.

Lectures by vendor representatives of lubricants, drives, motors, machinery, and other similar items.

Use specialized trade schools, such as for welding. Use public high school mechanical trade courses, equipment suppliers' training courses and visual aids.

Maintain a library of reference books, TAPPI reports, magazines, etc.

Give subscriptions to trade and maintenance magazines.

Create a list of machines and hand tools in order of importance. Spend your budget on those items rated most essential. Watch your newspaper ads and check against your list. Many used machine tools can be purchased reasonably and overhauled to give trainees practice. A coat of paint covers many a budget stretching value.

OUTSIDE SPECIALIZED SERVICE

Use services of specialized contractors when cheaper than using regular maintenance men, such as roofers, window cleaners, elevator and building maintenance, waste disposal, etc. There are many specialized jobs in the plant, such as fire safety consultants, that it just isn't reasonable or wise to expect even the largest organization to be prepared to tackle.

Most shops seldom require equipment like a radial drill, surface grinder, or planer. Locate this type of equipment for regular or emergency needs. They may be found in machine shops or local production plants. Meet the manager so that they will give you emergency telephone numbers and service. Give them some regular work if they want it to keep their good will.

AREA AND LOCATION

There is no formula for space allocation other than to use common sense. Plants with older equipment need more space. Plants with newer machines require replacements rather than reworking obsolete parts. Replacement requires less skill and space than repairs. This may be a key to maintenance that will come with more automation.

Try to keep work areas away from excessive heat and discomfort factors, such as closeness to corrugators and boilers. Some of the highest paid men in our wage scale work here and should be kept most efficient. Maintenance men usually work overtime and we should keep them fresh and satisfied as to working conditions.

Machine shop areas are comparatively easy to move, expand, or contract, as wiring is light and most machines move as complete, compact units.

Try to keep raw material racks and supply storerooms near working areas. It is scarcely necessary to remind you of the need for an inventory and antipilferage program. Many a private home has been partly constructed on "requisitioned" items. Set responsibilities and duties to combat this problem. Make maintenance responsible to determine their own inventory requirements.

MAINTENANCE COST

You just can't compare your maintenance costs with other plants!

The Fibre Box Association has developed a universal cost system which enables us to compare similar account headings, yet only about 50 companies use this method. Several other independent groups, like the Hankins or Container Conference Group, have been formed for "cost comparison" purposes.

This is a good step forward—but our industry can find no yardstick for its own individual performance. It's like trying to tell how much brains the other man has by his hat size.

The key to it all is what should it cost in *your plant?* Evaluate the age and condition of your machines, types of operation of short or long runs, crews and caliber of operators, efficiency of maintenance, quality of maintenance, and labor costs in your locality. Remember highly mechanized plants require more maintenance. More shifts per unit wear out machines in direct ratio to hours run.

Evaluate all the above and more, then set your own budgets.

Maintenance is in a good position to help production and cost personnel make a survey of pieces per hours, size range, and regularity of breakdowns in determining obsolescence. Changing to another drive or correcting a minor error in design may speed up a machine to new equipment potential. Flap cutters can be made from obsolete automatic tapers. There is no end to the ingenuity that has been and can be shown in our industry.

The future of our industry is tied to our progress in low cost production. Modern and progressive equipment manufacturers are important. Export your obsolete equipment to

help them and us. They are glad to cooperate in new designs and ideas. Take-off tables, slotter stackers, and right angle slitters are but a few of the machines developed by our maintenance departments and then produced by regular manufacturers.

Equipment manufacturers will send competent mechanics to work with maintenance crews in evaluating overhauls or making repairs. They will graciously teach your men at the same time.

Many a newly installed machine was accepted by production personnel because maintenance did its part in locating minor problems and correcting them before the operator became prejudiced.

WAYS TO LOW COST MAINTENANCE

Set up a responsible organization.
Use a work order system.
Keep equipment records.
Analyze and plan jobs.
Make weekly forecasts with operating departments for possible work.
Prepare duty schedules today for tomorrow.
Set a manpower control. Set a material control.
Set up a preventive maintenance program.
Use budgetary controls.
Plan plant shutdowns.
Set up major overhaul procedures and include probably tools, methods, and parts.
Develop standard practices and repair tool kits.
Use work measurements for repetitive jobs.
Improve your manufacturing equipment in design, materials, or replacement parts.
Train your supervisors.
Train your maintenance man.
Question every high-cost job.
Schedule maintenance overtime.
Have a lubrication evaluation made by competent engineers or oil company.
Make an analysis to standardize drives, belts, fuses, motors, etc.

Set up an incentive system. Less than 10% of companies have maintenance workers on incentives. This is probably due to general difficulty of establishing standards. You may use supervisors, individuals, or groups, in setting standards.

Make regular progress reports to top management and capitalize on the opportunity. Report backlog of work load. Point out why you are undermanned, as almost every report claims. Report machine down time caused by breakdowns and show if the price is due to failure to provide maintenance. Above all show completion of planned work.

Maintenance stands today, at the same threshold of opportunities to improve itself, where production stood a generation ago. Automation is the necessary goal of our industry, and without maintenance there can be no automation.

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References: Maintenance Engineering Handbook, L. C. Morrow, McGraw-Hill, and *Factory Maintenance and Management* magazine.

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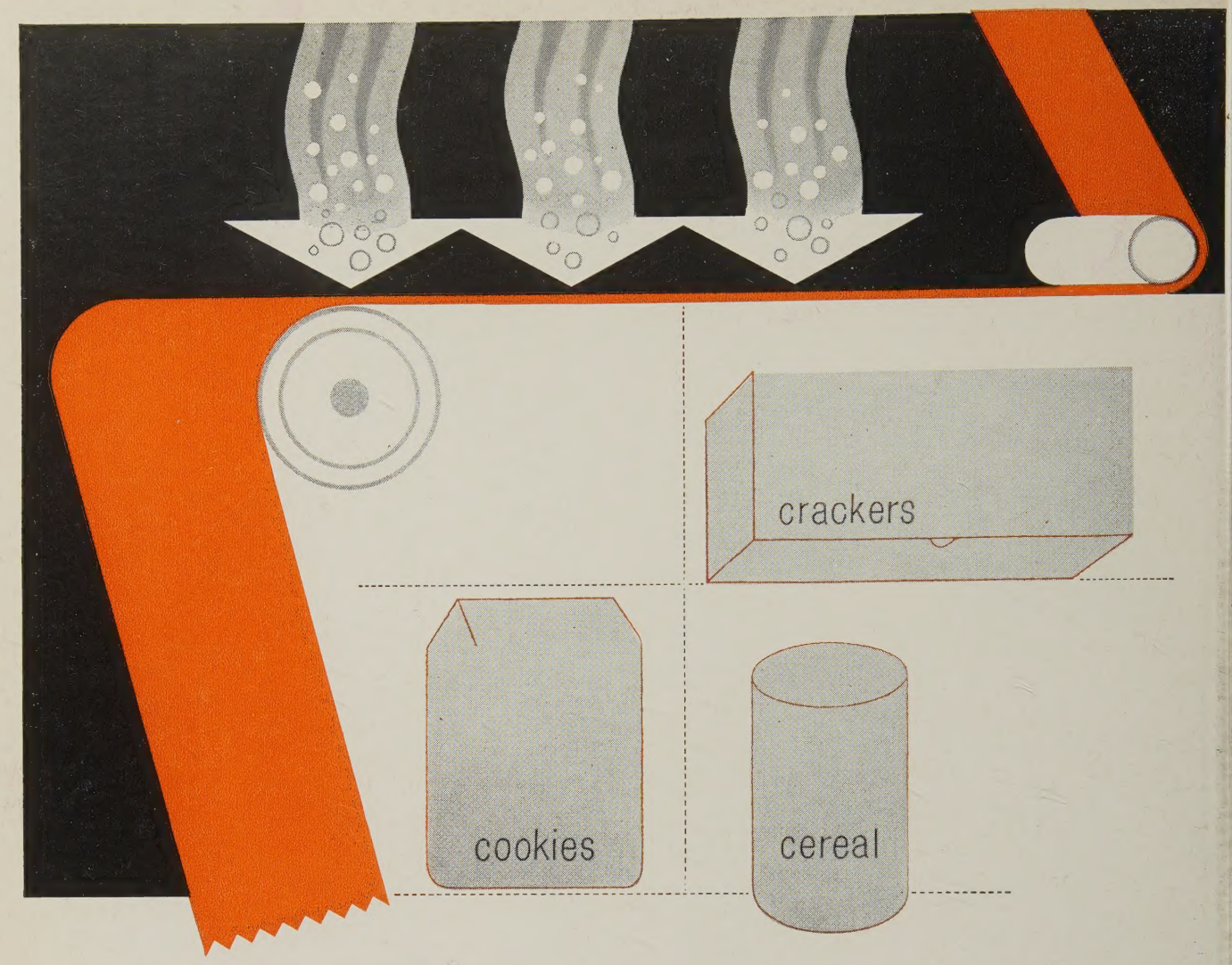

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